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VOLUME 19 NOVEMBER, 1945 NUMBER 6

THE FORAMINIFERAL FAUNA OF THE ANAHUAC FORMATION

JOSEPH A. CUSHMAN AND ALVA C. ELLISOR
Sharon, Massachusetts and Houston, Texas

ABSTRACT—The foraminiferal fauna of the Anahuac formation ("Middle Oligocene") of Texas is given in detail and most of the forms figured. Specimens were derived from deep well samples. Fifteen new species and seven new varieties are described.

THE NAME, Anahuac formation, has recently been given to the "Middle Oligocene" beds of Texas including, from base to top, the *Marginulina*, *Heterostegina*, and *Discorbis* zones. Some of the species occurring in the Anahuac formation have already been refigured in the paper by the junior author defining the formation ("Anahuac Formation," 1944, Amer. Assoc. Petr. Geol. Bull., vol. 28, no. 9, pp. 1355–1375, text figs. 1, 2, pls. 1–7). These were published earlier as noted in the same paper. Readers are referred to this paper for the stratigraphic details of the Anahuac formation.

The species that were published earlier are referred to in their proper places in this paper but are not refigured. A number of new species and varieties were found and these are here described and figured.

We wish to thank Mr. Morgan J. Davis and the directors of the Humble Oil and Refining Company for permission to publish on this fauna; also Mrs. Charles Lee for her help in picking out the Foraminifera, and Miss Ruth Todd for help in typing the manuscript and in the preparation of the plates which were made at the Cushman Laboratory by the senior author.

Family SACCAMMINIDAE
Genus PROTEONINA Williamson, 1858
PROTEONINA DIFFLUGIFORMIS (H. B. Brady)
Plate 71, figure 1

This species has a long range. Although usually crushed, the Anahuac specimens are fairly typical. The figured specimen is from Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, from core at 7438–7448 feet. It occurs in both the *Heterostegina* and *Marginulina* zones.

Family REOPHACIDAE
Genus REOPHAX Montfort, 1808
REOPHAX MORRISONI Cushman and Ellisor, n. sp.
Plate 71, figures 2–4

Test elongate, slightly tapering; chambers 5 to 6 in the adult test, about as long as broad, increasing only slightly in diameter as added, the apertural end somewhat contracted; sutures distinct but only slightly depressed; wall composed of fairly coarse sand grains with only a small amount of cement, surface somewhat roughened; aperture terminal, rounded, without a neck. Length 1.50–2.30 mm.; diameter 0.47–0.52 mm.

Holotype (Cushman Coll. 43007) from the *Heterostegina* zone of the Anahuac formation, in a core at 6867–6872 feet, Shell Oil Co. and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas. It also occurs in the *Marginulina* zone in cuttings from 9398–9428 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

This species differs from *R. nodulosus* H. B. Brady in the fewer and broader chambers, shorter and less tapering test, and coarser wall. It is named in honor of Mr. T. E. Morrison.

The test is usually somewhat compressed in fossilization but the last-formed chambers in the adult seem to be thicker and more resistant to distortion.

Family LITUOLIDAE
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES sp.
Plate 71, figure 5

These specimens are too much distorted to warrant a full description. They are from the *Marginulina* zone, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, core at 10,200–10,210 feet. They somewhat resemble the type of *H. dibollensis* Cushman and Applin from the Eocene.

Genus AMMOBACULITES Cushman, 1910
AMMOBACULITES cf. A. FOLIACEUS (H. B. Brady)
Plate 71, figure 6

Specimens from both the *Marginulina* and *Discorbis* zones are very close to Brady's species. As in Recent specimens, there is considerable variation in the amount of compression of the test and the number of chambers. The figured specimen is from Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, from a core at 7733–7743 feet.

Family TEXTULARIIDAE
Genus TEXTULARIA Defrance, 1824
TEXTULARIA TEASI Cushman and Ellisor

Textularia teasi Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 2, pl. 1, fig. 3.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 1; idem, 1944, vol. 28, no. 9, pl. 7, fig. 1.

This is more or less a marker for the *Discorbis* zone of the Anahuac formation. Forms similar to it occur in the *Heterostegina* zone.

TEXTULARIA ANAHUACANA Cushman and Ellisor, n. sp.
Plate 71, figure 7

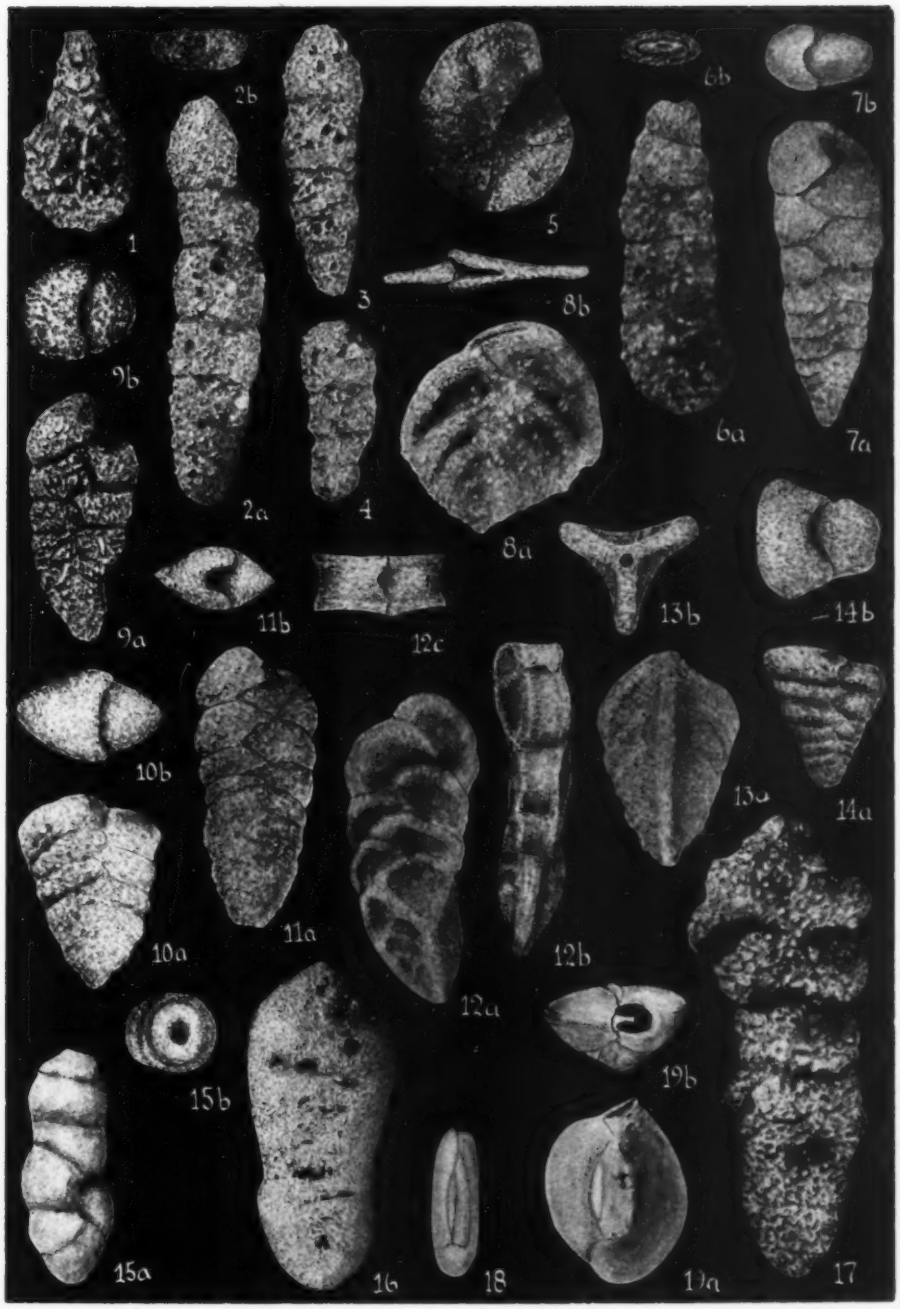
Test elongate, slender, gradually tapering from the subacute initial end to the greatest breadth formed by the last two chambers in the adult, somewhat compressed, periphery broadly rounded; chambers distinct, numer-

---

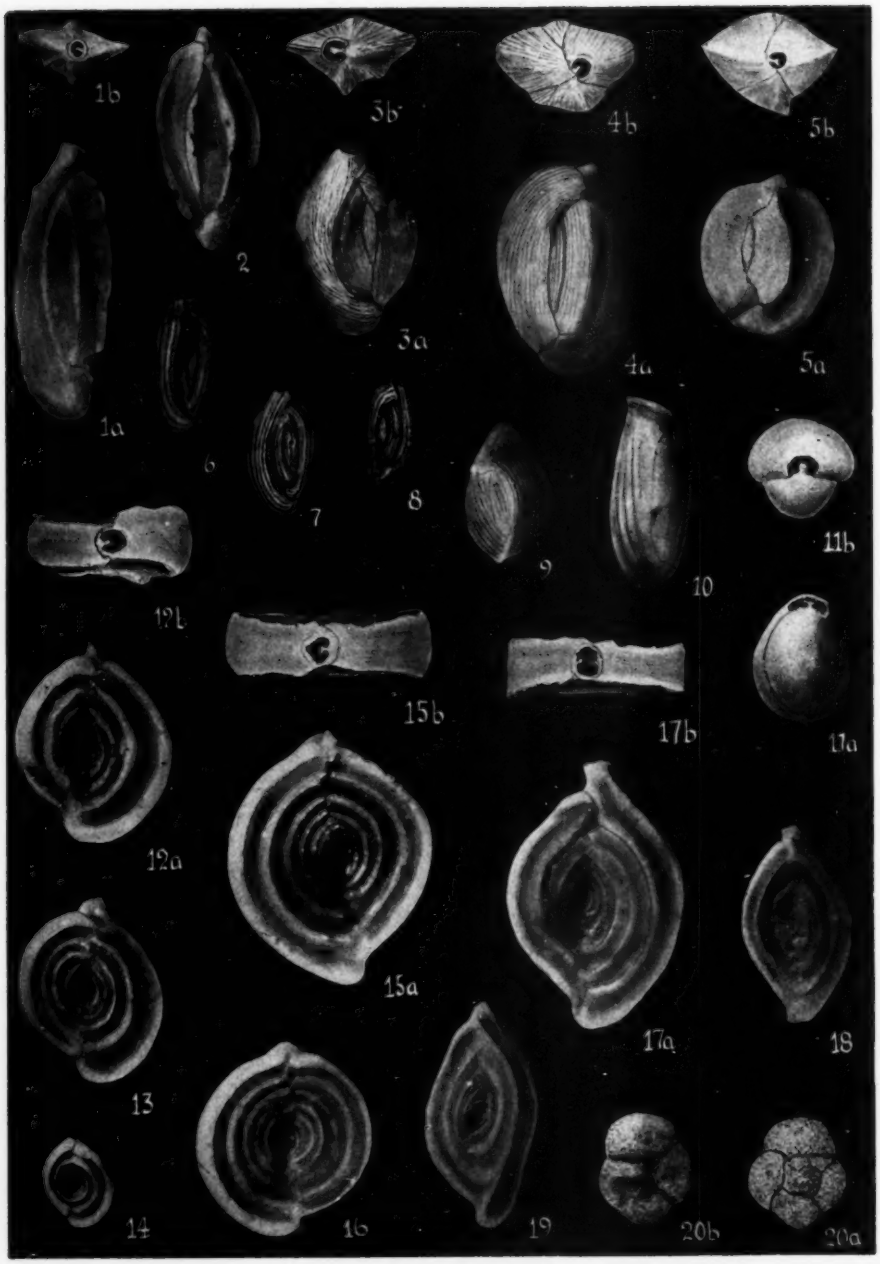
EXPLANATION OF PLATE 71

(Unless otherwise noted: *a*, front view; *b*, apertural view.)

FIGS. *1*—*Proteonina difflugiformis* (H. B. Brady). ×50. (p. 545)
2–4—*Reophax morrisoni* Cushman and Ellisor, n. sp. ×25. *2*, Holotype. *3*, *4*, Paratypes. (p. 545)
5—*Haplophragmoides* sp. ×35. (p. 546)
6—*Ammobaculites* cf. *A. foliaceus* (H. B. Brady). ×50. (p. 546)
7—*Textularia anahuacana* Cushman and Ellisor, n. sp. ×50. (p. 546)
8—*Textularia dentimarginata* Nuttall. ×50. (p. 547)
9—*Textularia mornhinvegi* Garrett. ×35. (p. 547)
10—*Textularia isidroensis* Cushman and Renz. ×35. (p. 547)
11—*Textularia articulata* d'Orbigny. ×50. (p. 547)
12—*Gaudryina* (*Pseudogaudryina*) *exornata* Cushman and Ellisor, n. sp. ×50. *a*, Front view; *b*, side view; *c*, apertural view. (p. 548)
13—*Clavulinoides depressa* Cushman and Ellisor, n. sp. ×60. (p. 548)
14—*Textulariella* sp. ×60. (p. 548)
15—*Plectina humblei* Cushman and Ellisor, n. sp. ×60. (p. 548)
16—*Liebusella byramensis turgida* (Cushman). ×25. (p. 549)
17—*Liebusella byramensis extans* (Cushman). ×25. (p. 549)
18—*Quinqueloculina* cf. *Q. vicksburgensis* Cushman. ×60. (p. 549)
19—*Quinqueloculina* cf. *Q. vulgaris* d'Orbigny. ×25. (p. 549)



Cushman and Ellisor—Oilgocene Foraminifera



Cushman and Ellisor—Oilgocene Foraminifera

ous, increasing rapidly in height in the adult portion but very gradually in width, very slightly inflated; sutures distinct, slightly depressed in the adult portion, nearly at right angles to the elongate axis of the test; wall very finely arenaceous, rather smoothly finished; aperture curved, a low opening at the inner border of the last-formed chamber. Length 0.85–1.00 mm.; breadth 0.30–0.35 mm.; thickness 0.20–0.24 mm.

Holotype (Cushman Coll. 43016) from the *Marginulina* zone of the Anahuac formation, from cuttings at 9367–9398 feet in the Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

TEXTULARIA DENTIMARGINATA Nuttall
Plate 71, figure 8

Textularia dentimarginata Nuttall, 1932, Jour. Paleontology, vol. 6, p. 6, pl. 1, fig. 2.—Franklin, 1944, idem, vol. 18, p. 306, pl. 44, fig. 25.

Specimens from the *Heterostegina* zone of the Anahuac formation were compared with the types from the Oligocene, Alazan formation, of Mexico, and seem identical. They are from cuttings at 8937–8967 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. Specimens from the lower Oligocene, Carapita formation, of Venezuela have been referred by Franklin to this species. Mrs. Palmer has referred specimens from the upper Oligocene, Cojimar formation, of Cuba to this species with some question (1940, Soc. cubana hist. nat. Mem., vol. 14, p. 113, pl. 17, fig. 18), but the sutures as figured seem quite different.

TEXTULARIA MORNHINVEGI Garrett
Plate 71, figure 9

Textularia mornhinvegi Garrett, 1939, Jour. Paleontology, vol. 13, p. 575, pl. 65, figs. 1, 2.

The types of this species are from the middle Tertiary (*Heterostegina* zone) of Jefferson Co., Texas. Specimens from this zone have been compared with metatypes and seem identical. They are from cuttings at 9153–9183 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas; and from core at 7262–7272 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

TEXTULARIA ARTICULATA d'Orbigny
Plate 71, figure 11

Textularia articulata d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 250, pl. 15, figs. 16–18.

This species was originally described from the Miocene of the Vienna Basin. Our Texas specimens have been compared with topotypes and are very similar, in fact more closely alike than other later figured specimens referred to d'Orbigny's species. The species has been recorded from the Miocene and Oligocene of America. Our specimens are from cuttings at 6887–6915 feet, Shell Oil Co. and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

TEXTULARIA ISIDROENSIS Cushman and Renz
Plate 71, figure 10

Textularia isidroensis Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 4, pl. 1, fig. 7.

EXPLANATION OF PLATE 72

(Unless otherwise noted: *a*, front view; *b*, apertural view.)

FIGS. *1, 2—Quinqueloculina glabrata* Cushman. *1*, ×60. *2*, ×25. (p. 549)
3—Quinqueloculina crassiformis Cushman and Ellisor, n. sp. ×25. (p. 549)
4—Quinqueloculina cf. *Q. crassa* d'Orbigny. ×25. (p. 550)
5—Quinqueloculina lustra Cushman. ×40. (p. 550)
6–8—Quinqueloculina subpoeyana Cushman. ×60. (p. 550)
9—Articulina advena (Cushman). ×40. (p. 552)
10—Articulina byramensis Cushman. ×40. (p. 552)
11—Pyrgo cf. *P. inornata* (d'Orbigny). ×50. (p. 552)
12–14—Spiroloculina alabastra Cushman and Ellisor. ×35. (p. 550)
15, 16—Spiroloculina texana Cushman and Ellisor. ×35. (p. 551)
17–19—Spiroloculina jucunda Cushman and Ellisor. ×35. (p. 551)
20—Trochammina teasi Cushman and Ellisor. ×50. *a*, Dorsal view; *b*, ventral view. (p. 552)

A few specimens from the *Heterostegina* zone, core at 7366–7376 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, seem identical with this species described from the lower Miocene, Agua Salada formation, of Venezuela.

Genus VULVULINA d'Orbigny, 1826

VULVULINA IGNAVA Garrett

Vulvulina ignava Garrett, 1939, Jour. Paleontology, vol. 13, p. 575, pl. 65, figs. 3–5.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 3–5.

This species is present in both the *Heterostegina* and *Marginulina* zones. Frequently the uniserial portion is not developed and the species has been overlooked or called *Textularia mississippiensis* Cushman.

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA (PSEUDOGANDRYINA) EXORNATA Cushman and Ellisor, n. sp.

Plate 71, figure 12

Test small, elongate, triserial portion with the sides concave, angles rounded, biserial portion irregularly quadrangular; chambers distinct, the sides concave, raised at the periphery, usually 5 or 6 in the biserial portion, increasing very gradually in size as added; sutures curved; wall composed of very fine sand grains with a large amount of cement, surface fairly smooth; aperture an elongate, narrow opening, the long axis parallel to the inner margin of the chamber, with a very slight neck. Length 0.65–0.90 mm.; breadth 0.30–0.37 mm.

Holotype (Cushman Coll. 43027) from the *Heterostegina* zone of the Anahuac formation, cuttings at 8688–8718 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

The species differs from *Gaudryina* (*Pseudogaudryina*) *jacksonensis* Cushman in the smaller size, more depressed chamber walls and raised periphery, and the quadrangular shape of the biserial portion in end view.

Genus CLAVULINOIDES Cushman, 1936

CLAVULINOIDES DEPRESSA Cushman and Ellisor, n. sp.

Plate 71, figure 13

Test triangular in section throughout, tapering, with the greatest breadth near the apertural end, sides deeply depressed, angles rounded; chambers indistinct, increasing very slightly in height as added; sutures slightly depressed; wall coarsely arenaceous, but the surface fairly smooth; aperture terminal, small, with a slight lip. Length 1.25–1.40 mm.; diameter 0.75–0.95 mm.

Holotype (Cushman Coll. 43030) from the *Heterostegina* zone of the Anahuac formation, in a core at 9122–9153 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

This species differs from *Clavulinoides triangularis* (Nuttall) in the deeply depressed sides and very rapidly tapering test.

Family VALVULINIDAE

Genus TEXTULARIELLA Cushman, 1927

TEXTULARIELLA sp.

Plate 71, figure 14

A few specimens from a core at 7262–7272 feet in Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, evidently belong to this genus but are not sufficiently well preserved as to details to warrant a description.

Genus PLECTINA Marsson, 1878

PLECTINA HUMBLEI Cushman and Ellisor, n. sp.

Plate 71, figure 15

Test elongate, about 2½ times as long as broad, generally circular in transverse section, the early portion considerably broader than the later uniserial portion; chambers fairly distinct, slightly inflated, only two or three in the uniserial portion; sutures slightly depressed, fairly distinct; wall finely arenaceous with a large amount of cement, surface smoothly finished; aperture terminal, circular, with a slight lip. Length 0.60–0.70 mm.; diameter 0.25–0.28 mm.

Holotype (Cushman Coll. 43035) from the *Discorbis* zone of the Anahuac formation, in cuttings at 8202–8216 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

This species differs from *Plectina elongata* Cushman and Bermudez in the smaller size, smoother wall, and slenderer uniserial portion. It is named in honor of the directors of the Humble Oil and Refining Company.

Genus LIEBUSELLA Cushman, 1933
LIEBUSELLA BYRAMENSIS TURGIDA
(Cushman)
Plate 71, figure 16

Clavulina byramensis turgida Cushman, 1923, U. S. Geol. Survey Prof. Paper 133, p. 22, pl. 2, figs. 4, 5.
Liebusella byramensis turgida Cushman, 1935, idem, Prof. Paper 181, p. 11, pl. 2, fig. 9.—Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 8, p. 165, pl. 19, figs. 20, 21.

This variety is a characteristic one of the Oligocene. The figured specimen is one of a large series from the *Heterostegina* zone, core at 7386–7396 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

LIEBUSELLA BYRAMENSIS EXTANS
(Cushman)
Plate 71, figure 17

Clavulina byramensis extans Cushman, 1923, U. S. Geol. Survey Prof. Paper 133, p. 22, pl. 2, fig. 6.—Howe, 1928, Jour. Paleontology, vol. 2, p. 174.—Cole and Ponton, 1930, Florida Geol. Survey Bull. 5, p. 29, pl. 9, fig. 9.—Cole and Gillespie, 1930, Bull. Am. Paleontology, vol. 15, no. 57b, p. 6, pl. 4, fig. 8.
Liebusella byramensis extans Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 8, p. 165, pl. 19, fig. 19.

This variety, found in the Oligocene of the Gulf Coastal Plain of the United States, is from the *Heterostegina* zone, cuttings at 9276–9306 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Family MILIOLIDAE
Genus QUINQUELOCULINA d'Orbigny, 1826
QUINQUELOCULINA cf. Q. VICKSBURGENSIS
Cushman
Plate 71, figure 18

A few specimens from the *Heterostegina* zone, core at 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas, may be the young of this Oligocene species (1922, U. S. Geol. Survey Prof. Paper 129-F, p. 141, pl. 34, fig. 6).

QUINQUELOCULINA cf. Q. VULGARIS
d'Orbigny
Plate 71, figure 19

Numerous specimens from both the *Heterostegina* and *Marginulina* zones are close to this species as figured from the Oligocene of Mississippi (1922, U. S. Geol. Survey Prof. Paper 129-F, p. 142, pl. 32, figs. 9, 10), although the series shows considerable variation in the inflation of the chambers. The figured specimen is from the *Heterostegina* zone, cuttings at 9337–9367 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, and it also occurs in the same well in the *Marginulina* zone, in cuttings from 9704–9734 feet.

QUINQUELOCULINA GLABRATA Cushman
Plate 72, figures 1, 2

Quinqueloculina glabrata Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-F, p. 141, pl. 34, fig. 8.—Cushman, 1923, idem, Prof. Paper 133, p. 52.—Applin, 1925, Am. Assoc. Petroleum Geologists Bull., vol. 9, p. 24.

This species, a characteristic one of the middle Oligocene of Mississippi and recorded from the Oligocene of Texas, occurs in typical form in core material from 5630–5652 feet, *Heterostegina* zone, in the Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas. The figured specimens show both young and adult stages.

QUINQUELOCULINA CRASSIFORMIS
Cushman and Ellisor, n. sp.
Plate 72, figure 3

Test about 1½ times as long as broad, periphery bluntly rounded to sharply angled; chambers distinct, triangular in transverse section, the periphery varying from bluntly rounded in the early stages to sharply angled or even slightly keeled in the adult, basal end somewhat extended, apertural end slightly so; sutures distinct, slightly depressed; wall ornamented with fine costae, usually slightly oblique to the periphery, especially in the later chambers; aperture terminal, with a slight neck and lip, the inner margin with a distinct tooth tending to become bifid. Length 0.80–1.10 mm.; breadth 0.55–0.75 mm.

Holotype (Cushman Coll. 43051) from the *Heterostegina* zone of the Anahuac formation, from cuttings at 9214–9245 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. Similar specimens also occur in the *Marginulina* zone.

This species differs from *Q. crassa*

d'Orbigny in the sharply angled chambers and oblique costae. It may be closely related to the Miocene form referred to *Q. crassa subcuneata* Cushman (Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 45, pl. 2, fig. 5) but these Miocene forms are not the same as the Recent types from the Philippines.

QUINQUELOCULINA cf. Q. CRASSA d'Orbigny
Plate 72, figure 4

Specimens very similar to these from the Anahuac formation have been referred to this species, especially from the middle Oligocene of the Gulf Coastal Plain (1922, U. S. Geol. Survey Prof. Paper 129-E, p. 102, pl. 27, figs. 1, 2). The figured specimen is one of a series from the *Marginulina* zone, core at 7458–7468 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. The costae are nearly parallel to the periphery, which is broadly rounded.

QUINQUELOCULINA LUSTRA Cushman
Plate 72, figure 5

Quinqueloculina lustra Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-F, p. 141, pl. 33, fig. 6.—Cushman, 1923, idem, Prof. Paper 133, p. 53.

A few specimens from the *Heterostegina* zone, at 9122–9153 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, seem to be identical with this species described from the middle Oligocene of Mississippi.

QUINQUELOCULINA SUBPOEYANA Cushman
Plate 72, figures 6–8

Quinqueloculina subpoeyana Cushman, 1922, Carnegie Inst. Washington Publ. 311, p. 66.—Cushman, 1929, U. S. Nat. Mus. Bull. 104, pt. 6, p. 31, pl. 5, fig. 3.—Cushman, 1930, Florida Geol. Survey Bull. 4, p. 21, pl. 2, fig. 7.—Cushman and Ponton, 1932, Bull. 9, p. 44, pl. 2, fig. 4.—Cushman and Cahill, 1933, U. S. Geol. Survey Prof. Paper 175-A, p. 10, pl. 2, fig. 5.—Bermudez, 1935, Soc. cubana historia nat. Mem., vol. 9, p. 160.

The Oligocene specimens, when compared with Recent and Miocene specimens, seem to be identical. The species shows much variation in the regularity of the coiling, some specimens being typically quinqueloculine while others tend toward *Massilina*, or even *Spiroloculina*. The Anahuac specimens are from the *Heterostegina* zone, in a core from 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus SPIROLOCULINA d'Orbigny, 1826
SPIROLOCULINA ALABASTRA Cushman and Ellisor
Plate 72, figures 12–14

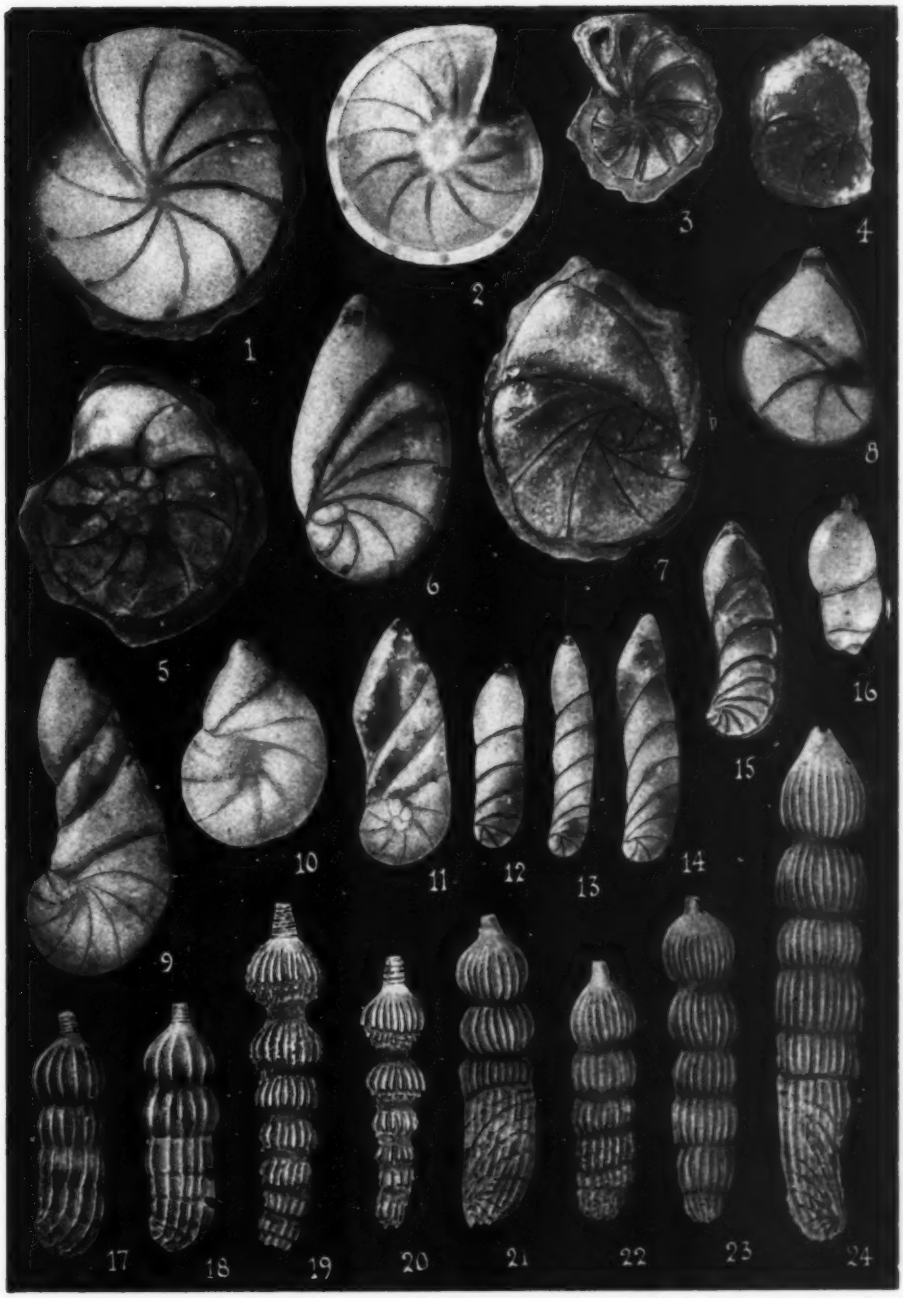
Spiroloculina alabastra Cushman and Ellisor, 1944, Cushman Lab. Foram. Research Contr., vol. 20, p. 50, pl. 8, figs. 11–13.—Cushman and Todd, 1944, idem, Spec. Publ. no. 11, p. 18, pl. 3, fig. 15.

Test about 1½ times as long as broad, strongly concave, periphery flat or somewhat convex, distinctly thickened at the margins and sometimes irregularly serrate in the adult, in the young the margins are thin, sharp, and strongly raised and curved

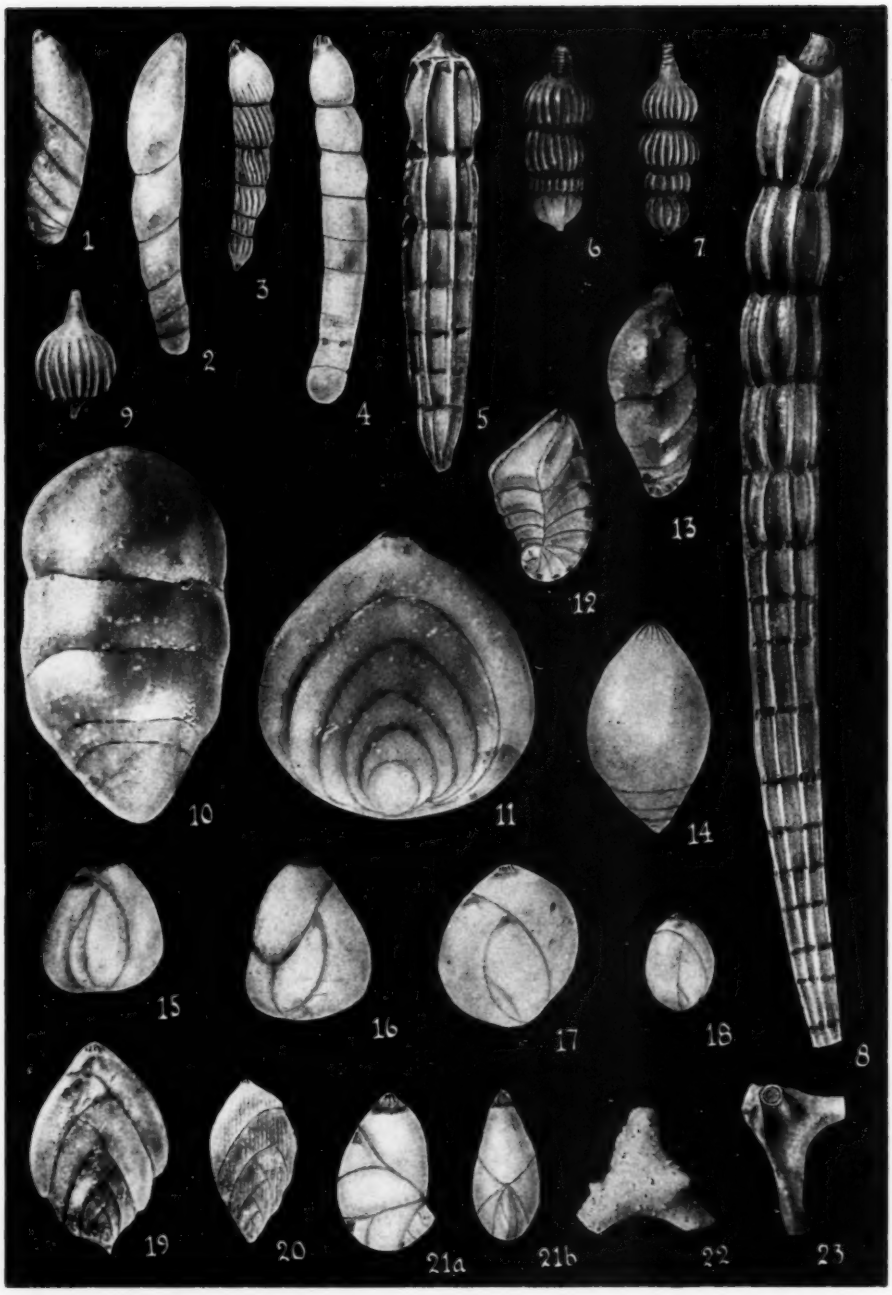
---

EXPLANATION OF PLATE 73

FIGS. *1*—*Robulus limbosus* (Reuss). ×50. (p. 552)
2—*Robulus iotus* (Cushman). ×30. (p. 553)
3—*Robulus* cf. *R. cultratus* Montfort. ×30. (p. 553)
4—*Robulus suteri* Cushman and Renz. ×50. (p. 553)
5—*Planularia arbenzi* Cushman and Renz. ×50. (p. 553)
6—*Planularia ovata* (Galloway and Heminway). ×50. (p. 554)
7, 8—*Planularia anahuacana* Cushman and Ellisor, n. sp. ×50. *7*, Holotype. *8*, Paratype. (p. 554)
9–15—*Marginulina sublituus* (Nuttall). ×50. Specimens showing the wide variation of this species. (p. 554)
16—*Marginulina abbreviata* Neugeboren. ×45. (p. 554)
17, 18—*Marginulina ellisi* Cushman and Ellisor, n. sp. ×50. *17*, Holotype, *18*, paratype. (p. 554)
19, 20—*Marginulina sorrentoensis* Howe and McDonald. ×50. (p. 555)
21–24—*Marginulina garretti* Cushman and Ellisor, n. sp. ×50. *24*, Holotype, *21–23*, paratypes. *21, 24*, Microspheric forms; *22, 23*, megalospheric. (p. 555)



Cushman and Ellisor—Oilgocene Foraminifera



Cushman and Ellisor—Oilgocene Foraminifera

inward resembling the petals of a rose; chambers numerous, as many as 12, evenly curved and of about equal width and thickness throughout, projecting bluntly at the basal end, at the apertural end extending into a short broad neck; sutures depressed, distinctly defined by the raised peripheral margins of the earlier chambers; wall smooth, polished; aperture circular, surrounded by a thickened rim, with a short, broad, simple tooth on the inner margin. Length 0.70–0.80 mm.; breadth 0.45–0.62 mm.; thickness 0.20–0.25 mm.

The types of this species are from the *Heterostegina* zone, core at 9183–9214 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

SPIROLOCULINA TEXANA
Cushman and Ellisor
Plate 72, figures 15, 16

Spiroloculina texana Cushman and Ellisor, 1944, Cushman Lab. Foram. Research Contr., vol. 20, p. 51, pl. 8, figs. 14, 15.—Cushman and Todd, 1944, idem, Spec. Publ. no. 11, p. 18, pl. 3, fig. 16.

Spiroloculina aff. *S. depressa* Nuttall, 1932, Jour. Paleontology, vol. 6, p. 8, pl. 1, fig. 3.

Test only slightly longer than broad, slightly concave in the early portion, periphery flat or slightly convex, distinctly thickened and raised at the margins; chambers distinct, numerous, as many as 17, very gradually increasing in size as added, evenly curved and of equal width and thickness throughout, each chamber appearing channeled in front view due to the raised peripheral margins, chambers projecting slightly and about equally at both ends; sutures distinct, depressed, defined by the raised peripheral rims of the previous chambers; wall smooth except where slightly roughened by minute discontinuous ines parallel to the curvature of the chambers; aperture small, circular, with a thickened rim and a short, broad, simple tooth on the inner margin. Length 0.70–0.95 mm.; breadth 0.57–0.77 mm.; thickness 0.20–0.25 mm.

The types of this species are from the same sample as the preceding. The species also occurs in the Oligocene, Alazan shale, of Mexico.

SPIROLOCULINA JUCUNDA
Cushman and Ellisor
Plate 72, figures 17–19

Spiroloculina jucunda Cushman and Ellisor, 1944, Cushman Lab. Foram. Research Contr., vol. 20, p. 51, pl. 8, figs. 16–18.—Cushman and Todd, 1944, idem, Spec. Publ. no. 11, p. 19, pl. 3, fig. 7.

Test 1½ to 2 times as long as broad, concave in the early portion, periphery flat, distinctly angled at the margins; chambers rapidly increasing in size as added, of equa width throughout, the central portion some

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EXPLANATION OF PLATE 74

FIGS. *1*—*Dentalina mesonensis* Cole and Gillespie. ×50. (p. 555)
2—*Dentalina* cf. *D. communis* d'Orbigny. ×50. (p. 556)
3—*Dentalina pseudoinvolvens* Cushman and McGlamery. ×42. (p. 556)
4—*Dentalina* cf. *D. alazanensis* (Nuttall). ×50. (p. 556)
5—*Nodosaria stainforthi* Cushman and Renz. ×50. (p. 556)
6, 7—*Nodosaria spinicosta* d'Orbigny. ×42. (p. 557)
8—*Nodosaria* cf. *N. vertebralis* (Batsch). ×50. (p. 556)
9—*Lagena costata* (Williamson), var. ×65. (p. 558)
10—*Lingulina mesonensis* Cole. ×30. (p. 557)
11—*Frondicularia alazanensis* Nuttall. ×30. (p. 558)
12—*Saracenaria schencki* Cushman and Hobson. ×40. (p. 557)
13—*Saracenaria* cf. *S. acutauricularis* (Fichtel and Moll). ×40. (p. 557)
14—*Glandulina* cf. *G. laevigata* (d'Orbigny). ×50. (p. 559)
15—*Guttulina byramensis* (Cushman). ×50. (p. 558)
16—*Guttulina irregularis* d'Orbigny. ×50. (p. 558)
17—*Globulina gibba* d'Orbigny. ×50. (p. 558)
18—*Globulina inaequalis* Reuss. ×42. (p. 559)
19—*Polymorphina frondea* (Cushman). ×42. (p. 559)
20—*Polymorphina advena* Cushman. ×42. (p. 559)
21—*Polymorphinella curta* Cushman and Ellisor, n. sp. ×50. *a*, Side view; *b*, peripheral view. (p. 559)
22, 23—*Ramulina* cf. *R. laevis* Jones. ×42. (p. 559)

what depressed and channeled, the outer ridge overlapped by the succeeding chamber, projecting in a blunt point at the basal end, extending into a long cylindrical neck at the apertural end; sutures distinct, depressed; wall smooth; aperture circular, at the end of the neck, with a very slight inward projection on the inner margin. Length 0.85–1.00 mm.; breadth 0.45–0.68 mm.; thickness 0.17–0.20 mm.

The types of this species are from the *Heterostegina* zone, core at 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co. Texas. Somewhat similar specimens occur in the Oligocene, Alazan shale, of Mexico.

Genus ARTICULINA d'Orbigny, 1826
ARTICULINA BYRAMENSIS Cushman
Plate 72, figure 10

Articulina byramensis Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-E, p. 103, pl. 27, figs. 5, 6.—Cushman, 1922, idem, Prof. Paper 129-F, p. 143; 1923, Prof. Paper 133, p. 56.—Howe, 1928, Jour. Paleontology, vol. 2, p. 174 (list).—Cushman and Hanzawa, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 45.—Cushman, 1944, idem, Spec. Publ. no. 10, p. 7, pl. 1, figs. 18, 19.

This is a characteristic species of the middle Oligocene of the Gulf Coastal Plain of the United States. The Anahuac specimens have the surface somewhat worn and the costae are not as high in most specimens as in the types, but are otherwise similar. They are from the *Heterostegina* zone, in a core from 7346–7356 feet in the Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

ARTICULINA ADVENA (Cushman)
Plate 72, figure 9

Vertebralina advena Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-E, p. 102, pl. 25, figs. 5, 6.—Cushman, 1923, idem, Prof. Paper 133, p. 51.—Howe, 1928, Jour. Paleontology, vol. 2, p. 175 (list).—Cushman and Hanzawa, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 44.—Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 66, pl. 4, fig. 5.

Articulina advena Cushman, 1944, Cushman Lab. Foram. Research, Spec. Publ. no. 10, p. 8, pl. 1, figs. 20, 21.

Vertebralina cassis Cushman and Ponton (not d'Orbigny), 1932, Florida State Geol. Survey Bull. 9, p. 57, pl. 8, fig. 1.

This species is known from the middle Oligocene of Mississippi and Alabama and the Miocene of Florida. In the Anahuac material it occurs in the *Heterostegina* zone, in a core from 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus PYRGO Defrance, 1924
PYRGO cf. P. INORNATA (d'Orbigny)
Plate 72, figure 11

A few specimens somewhat resembling this species are from the *Heterostegina* zone, in a core from 7396–7406 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. They are similar to those figured from the Oligocene of Alabama (1938, U. S. Geol. Survey Prof. Paper 189-D, p. 104, pl. 24, figs. 6, 7). The species has also been recorded from the Oligocene of Washington and Porto Rico.

Family TROCHAMMINIDAE
Genus TROCHAMMINA Parker and Jones, 1859
TROCHAMMINA TEASI Cushman and Ellisor
Plate 72, figure 20

Trochammina teasi Cushman and Ellisor, 1931, Cushman Lab. Foram. Research Contr., vol. 7, p. 52, pl. 7, fig. 3.—Ellisor, 1933, Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, pl. 1, fig. 9.

This species was described from the upper Eocene of Texas. The Anahuac specimens are slightly smaller but otherwise seem to very similar. The figured specimen is from the *Discorbis* zone in a core from 4591–4609 feet in the Humble Oil and Refining Co.'s No. 1 Minnetex, Mykawa Field, Harris Co., Texas. It also occurs in the *Heterostegina* zone.

Family LAGENIDAE
Genus ROBULUS Montfort, 1808
ROBULUS LIMBOSUS (Reuss)
Plate 73, figure 1

One of a series of specimens is figured from the *Heterostegina* zone, cuttings at 8660–8719 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas. Similar specimens were found in the *Heterostegina* zone, in core samples from 6867–6872 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas. These are very similar to a specimen figured by Nuttall from the Alazan clays of Mexico

as "*Cristellaria kemperi* Hanna" (1932, Jour. Paleontology, vol. 6, p. 10, pl. 1, fig. 8) but not the same as that species. This species was described by Reuss from the Oligocene of Germany. It occurs in typical form in the American upper Eocene (Cushman, 1935, U. S. Geol Survey, Prof. Paper 181, p. 16, pl. 6, fig. 5) and is recorded from the Oligocene of Mexico and Cuba.

ROBULUS IOTA (Cushman)
Plate 73, figure 2

Cristellaria cultrata H. B. Brady (not Montfort), 1884, Challenger Rept., Zoology, vol. 9, p. 550, pl. 70, figs. 4–6.
Cristellaria iota Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 111, pl. 29, fig. 2; pl. 30, fig. 1.
Robulus iotus Cushman, 1930, Florida State Geol. Survey Bull. 4, p. 25, pl. 4, fig. 1.—Cushman and Ponton, 1932, idem, Bull. 9, p. 58.—Palmer and Bermudez, 1935, Soc. cubana historia nat. Mem., vol. 9, p. 241.—Asano, 1938, Tohoku Imp. Univ. Sci. Repts., ser. 2 (Geol.), vol. 19, no. 2, p. 202 (24), pl. 25 (2), figs. 7, 11; pl. 28 (5), figs. 1, 2.—Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 349, pl. 12, fig. 7.—LeRoy, 1941, Colorado School Mines Quart., vol. 36, no. 1, pt. 2, p. 73, pl. 6, figs. 7, 8.

The species seems to be widely distributed in the upper Oligocene and Miocene of the Western Hemisphere and in the Miocene and Pliocene of the Pacific Region. The figured specimens are from the *Marginulina* zone in Sun Oil Co.'s No. 1 Hamilton at 7773–7783 feet where it is fairly common.

ROBULUS cf. R. CULTRATUS Montfort
Plate 73, figure 3

Specimens, similar to the one figured, are fairly common in the *Marginulina* zone. The figured specimen is from a core at 10,200–10,210 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. The specimens show considerable variation in the amount of convexity and in the elevation of the sutures, characters which always seem to be variable in this group.

ROBULUS SUTERI Cushman and Renz
Plate 73, figure 4

Robulus suteri Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 10, pl. 2, figs. 5–8.

A few specimens from the *Heterostegina* zone, in cuttings from 8937–8967 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Col, Texas, seem identical with this species from the Oligocene of Venezuela.

ROBULUS LACERTUS Garrett

Robulus lacerta Garrett, 1939, Jour. Paleontology, vol. 13, p. 576, pl. 65, figs. 6, 7.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 6, 7.

This form occurs in both the *Heterostegina* and *Marginulina* zones.

ROBULUS CHAMBERSI Garrett

Robulus chambersi Garrett, 1939, Jour. Paleontology, vol. 13, p. 576, pl. 65, figs. 8, 9.—Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 347, pl. 12, fig. 1.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 8, 9.

This is the form referred to as "*Robulus clericii* (Fornasini)" by the junior author of this paper in her report on the Miocene of southern Louisiana (1940, Amer. Assoc. Petr. Geol. Bull., vol. 24, no. 3, pl. 1, fig. 7). The species occurs in all three zones of the Anahuac formation.

Genus LENTICULINA Lamarck, 1804
LENTICULINA JEFFERSONENSIS Garrett

Lenticulina jeffersonensis Garrett, 1939, Jour. Paleontology, vol. 13, p. 577, pl. 65, figs. 10–12.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 10–12.

Lenticulina jeffersonensis differs from *Robulus vaughani* (Cushman) in being less compressed, more tightly coiled, and with more prominently developed sutures. It occurs in all three zones of the Anahuac formation.

Genus PLANULARIA Defrance, 1824
PLANULARIA ARBENZI Cushman and Renz
Plate 73, figure 5

Planularia arbenzi Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 13, pl. 2, fig. 13.

Rare specimens from the *Discorbis* zone, cuttings from 8534–8566 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound,

Brazoria Co., Texas, seem to be identical with this species known from the Oligocene, Agua Salada formation, of Venezuela.

PLANULARIA OVATA
(Galloway and Heminway)
Plate 73, figure 6

Astacolus ovatus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 334, pl. 8, fig. 10.

A few specimens from the *Marginulina* zone from core at 10,200–10,210 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, are very similar to this species described from the Ponce formation of Puerto Rico.

PLANULARIA ANAHUACANA
Cushman and Ellisor, n. sp.
Plate 73, figures 7, 8

Test strongly compressed, sides completely flattened, periphery with a distinct, thin keel, strongly developed in the adult stage; chambers distinct, about six in the coil, slightly overlapping at the inner end, increasing gradually and rather evenly in size as added; sutures distinct, little if at all depressed, gently curved; wall smooth; aperture radiate, projecting. Length 0.60–0.95 mm.; breadth 0.45–0.65 mm.; thickness 0.07–0.10 mm.

Holotype (Cushman Coll. 43083) from the *Heterostegina* zone of the Anahuac formation, in cuttings from 8937–8967 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. The species occurs in some numbers in this zone.

The species differs from *P. arbenzi* Cushman and Renz in the fewer chambers which extend beyond the umbilical region and the less curved sutures. It is thin and fragile and easily broken in preparing the samples.

Genus MARGINULINA d'Orbigny, 1826
MARGINULINA SUBLITUUS (Nuttall)
Plate 73, figures 9–15

Cristellaria sublituus Nuttall, 1932, Jour. Paleontology, vol. 6, p. 11, pl. 1, figs. 13, 14.—Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 256.—Bermudez, 1938, idem, vol. 12, p. 2.

Marginulina sublituus Hedberg, 1937, Jour. Paleontology, vol. 11, p. 170.

Astacolus sublituus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 335, pl. 8, fig. 11.

Marginulina sp. Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 67, pl. 4, figs. 6, 7.

This species, described from the lower Oligocene of Mexico, has also been recorded from the Oligocene and Eocene of Venezuela, Cuba, Puerto Rico, and Alabama. Specimens from the Anahuac formation are very similar and occur in the *Discorbis* zone, cuttings from 8319–8349 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, and also from the *Heterostegina* zone, in core at 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. Even more typical specimens occur in the *Marginulina* zone, in core samples from 7605–7610 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

As in most species of this group. there is considerable variation in any large series. Some of these are shown on our plate. The specimens shown (pl. 73, figs. 9, 10) probably belong in this series, as there seem to be nearly complete stages in the material. They are also from the well at Halls Bayou.

MARGINULINA ABBREVIATA Neugeboren
Plate 73, figure 16

Marginulina abbreviata Neugeboren, 1851, Ver. Mitt. Siebenbürg Verh. Nat., Jahrg. 2, p. 129, pl. 5, fig. 4.

A few specimens from the *Heterostegina* zone, from cuttings at 8660–8691 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas, seem identical with this species. They show considerable variation.

MARGINULINA ELLISI Cushman and Ellisor, n. sp.
Plate 73, figures 17, 18

Test with the early portion slightly compressed and slightly coiled, the later portion rectilinear and circular in transverse section; chambers few, the early coiled ones compressed and low, increasing gradually in height in the adult stage, apertural end with a distinct, cylindrical neck; sutures

distinct, early ones limbate, not depressed, later ones becoming distinctly depressed in the adult; wall with a few longitudinal costae, 10 to 12 in number, mostly continuous throughout the length of the test, on the earlier chambers sharply bent giving a hook-like appearance; aperture at the end of a cylindrical neck which is marked by numerous, fine, horizontal costae. Length 1.00–1.25 mm.; diameter 0.30–0.45 mm.

Holotype (Cushman Coll. 43097) from the lower part of the *Marginulina* zone of the Anahuac formation, in a core at 7570–7575 feet, Shell Oil Co., and Humble Oil and Refining Co's No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

This species differs from *M. texana* Garrett and Ellis in the less abrupt change in diameter in development, and in the lower, less plate-like costae, which are strongly curved at the base. It is named in honor of Mr. A. D. Ellis, Jr.

MARGINULINA GARRETTI
Cushman and Ellisor, n. sp.
Plate 73, figures 21–24

Test elongate, slender, early portion coiled and compressed, later portion rectilinear; chambers distinct, earlier ones compressed and in the microspheric form coiled, in the megalospheric form only one or two showing signs of coiling, later ones globular, becoming distinctly separated; sutures distinct, early ones curved and somewhat limbate, later ones strongly depressed; wall of the early portion with numerous longitudinal costae continuous over the sutures, those at the periphery more strongly developed, in the adult numerous, 25 or more; aperture terminal, radiate, with a distinct neck. Length 1.00–2.00 mm.; diameter 0.25–0.35 mm.

Holotype (Cushman Coll. 43100) from the lower part of the *Heterostegina* zone of the Anahuac formation, in a core at 6867–6872 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

This species differs from *Marginulina vaginata* Garrett and Ellis in the more elongate test; the larger number of adult, globular chambers; and the much more numerous costae. It is named in honor of Mr. J. B. Garrett.

MARGINULINA SORRENTOENSIS
Howe and McDonald
Plate 73, figures 19, 20

Marginulina sorrentoensis Howe and McDonald, 1938, Louisiana Geol. Survey, Geol. Bull. 13, p. 210, pl. 1, figs. 5, 6.

Specimens from the *Discorbis* zone, cuttings at 8566–8597 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas, seem identical with this species described from Sorrento Dome, Louisiana. It seems a further development in the *Marginulina* series.

MARGINULINA VAGINATA Garrett and Ellis

Marginulina mexicana vaginata Garrett and Ellis, 1937, Jour. Paleontology, vol. 11, p. 630, pl. 86, figs. 2, 10–12, 17.—Palmer, 1940, Soc. cubana historia nat. Mem., vol. 14, p. 279, pl. 52, fig. 19.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 4, figs. 2, 10–12, 17.

Marginulina vaginata Garrett, 1939, Jour. Paleontology, vol. 13, p. 622.

This species differs from *M. mexicana* Cushman in several ways. It is broader, especially in the initial portion; has more and better developed longitudinal costae; and is more inflated in the final portion. This is the diagnostic species of the *Marginulina* zone.

MARGINULINA IDIOMORPHA
Garrett and Ellis

Marginulina idiomorpha Garrett and Ellis, 1937, Jour. Paleontology, vol. 11, p. 631, pl. 86, figs. 5, 6, 13, 14.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 4, figs. 5, 6, 13, 14.

This species occurs in both the *Heterostegina* and *Marginulina* zones.

MARGINULINA HOWEI Garrett and Ellis

Marginulina howei Garrett and Ellis, 1937, Jour. Paleontology, vol. 11, p. 631, pl. 86, figs. 8, 9, 18.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 4, figs. 8, 9, 18.

This species is characteristic of the *Marginulina* zone and in some areas makes an excellent horizon marker.

Genus DENTALINA d'Orbigny, 1826
DENTALINA MESONENSIS
Cole and Gillespie
Plate 74, figure 1

Dentalina mesonensis Cole and Gillespie, 1930, Bull. Am. Paleontology, vol. 15, no. 57*b*, p. 8, pl. 4, fig. 7.

Specimens from the *Discorbis* zone, cuttings at 8668–8688 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, are similar to this species, described from the Oligocene, Meson formation, of Mexico. There is a considerable range of form in megalospheric and microspheric specimens, as is usual in this genus.

DENTALINA cf. D. COMMUNIS d'Orbigny
Plate 74, figure 2

Specimens from the *Heterostegina* zone, from core at 7252–7262 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, are related to this species. Some of the extreme microspheric specimens tend toward *Marginulina*.

DENTALINA PSEUDOINVOLVENS
Cushman and McGlamery
Plate 74, figure 3

Dentalina pseudoinvolvens Cushman and McGlamery, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 45, pl. 9, figs. 1, 2; 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 67, pl. 4, figs. 8, 9.

This species, described from the Oligocene, Chickasawhay marl, of Alabama, seems to be present in the Anahuac formation, in the *Discorbis* zone, in cuttings from 7630–7645 feet, Amerada Oil Co.'s No. 1 Houston Farms Development Co., Brazoria Co., Texas.

DENTALINA cf. D. ALAZANENSIS (Nuttall)
Plate 74, figure 4

A few specimens from the *Marginulina* zone are somewhat similar to the form described by Nuttall from the Oligocene, Alazan shale, of Mexico (1932, Jour. Paleontology, vol. 6, p. 13, pl. 3, figs. 3, 7). The Anahuac specimens are from cuttings at 10,449–10,459 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Genus NODOSARIA Lamarck, 1812
NODOSARIA STAINFORTHI
Cushman and Renz
Plate 74, figure 5

Nodosaria stainforthi Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 15, pl. 3, fig. 4.—Renz, 1942, 8th Am. Sci. Congress Proc., p. 556 (list).

This species was described from the Agua Salada formation of Venezuela. Very similar specimens occur in the *Discorbis* zone, in cuttings from 8597–8629 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

NODOSARIA cf. N. VERTEBRALIS (Batsch)
Plate 74, figure 8

A few specimens from the *Heterostegina* zone, cuttings at 9254–9285 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms

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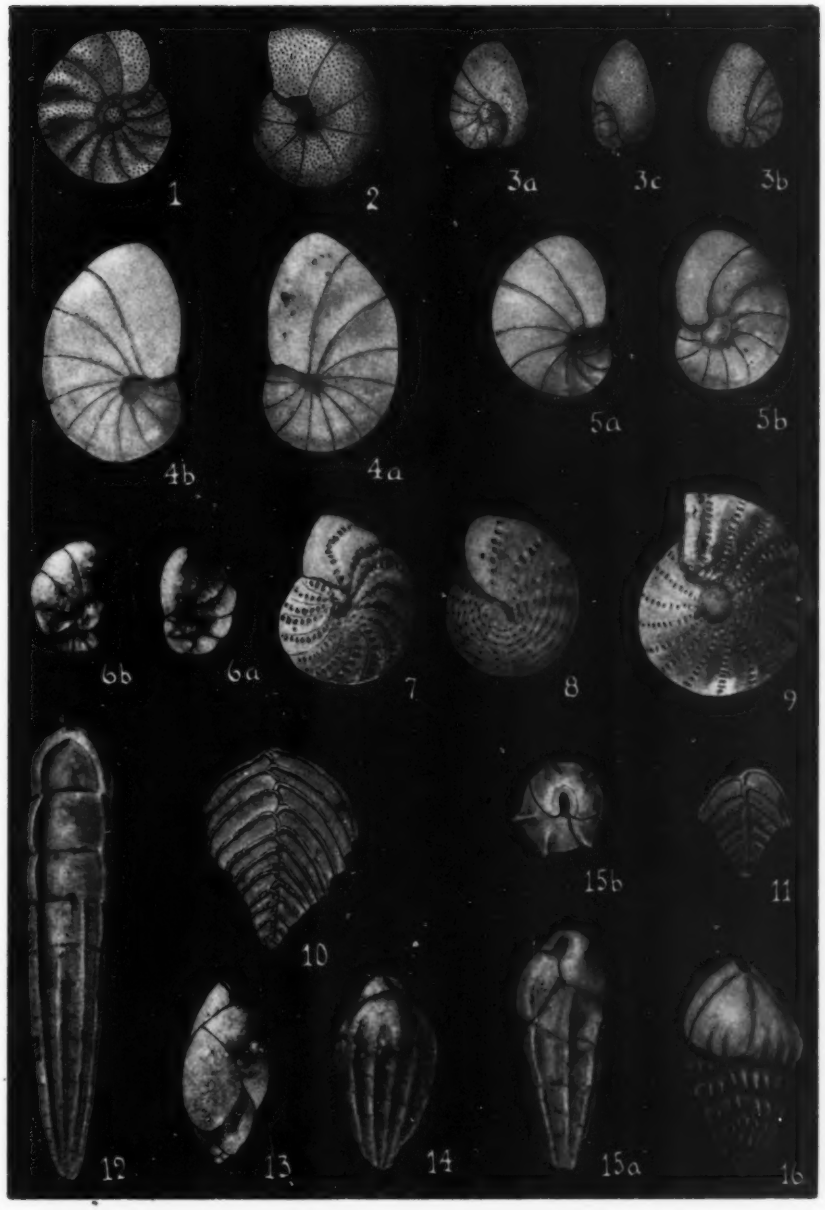
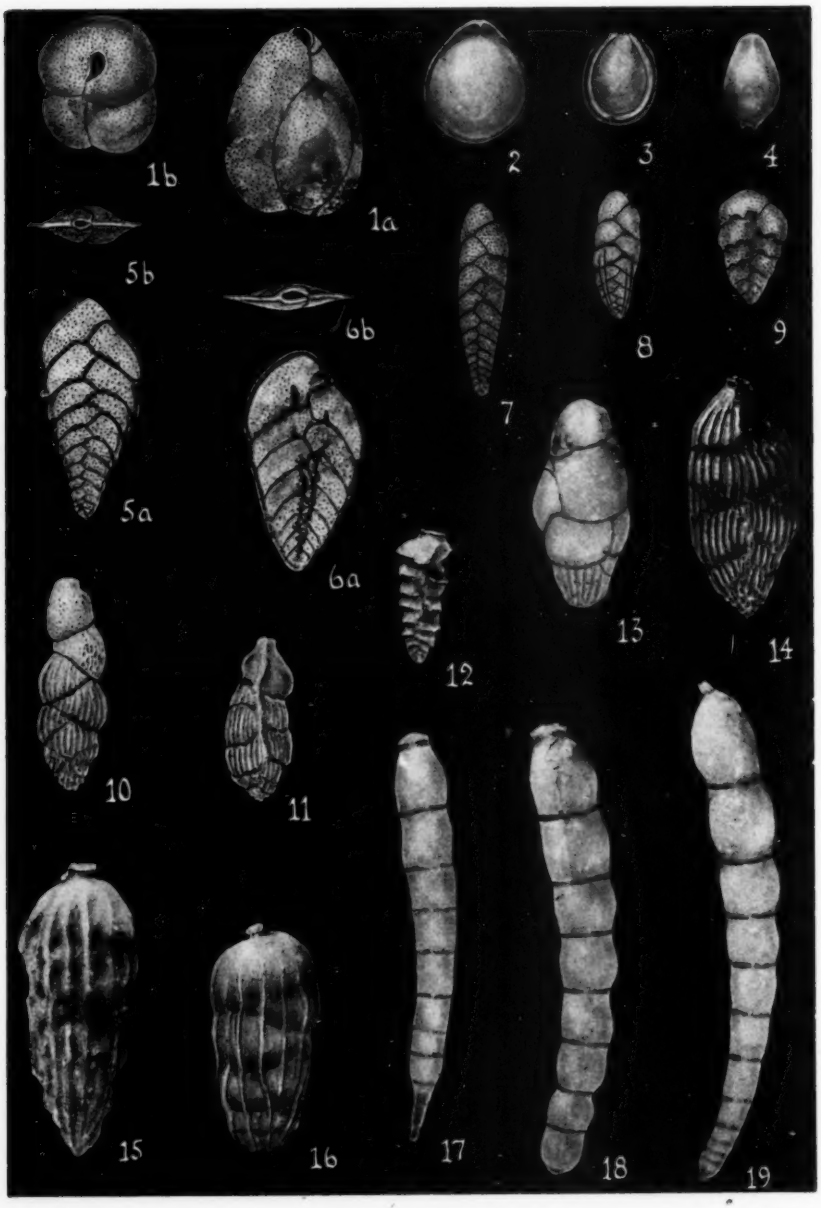
EXPLANATION OF PLATE 75

FIGS. *1*—*Nonion advenum* (Cushman). ×55. (p. 560)
2—*Nonion affine* (Reuss). ×55. (p. 560)
3—*Nonionella crassipunctata* Cushman. ×55. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view. (p. 560)
4—*Nonionella hantkeni* (Cushman and Applin). ×55. *a*, Dorsal view; *b*, ventral view. (p. 560)
5—*Nonionella hantkeni spissa* Cushman. ×55. *a*, Dorsal view; *b*, ventral view. (p. 560)
6—*Nonionella* cf. *N. jacksonensis* Cushman. ×55. *a*, Dorsal view; *b*, ventral view. (p. 560)
7—*Elphidium advenum* (Cushman). ×42. (p. 560)
8—*Elphidium sagrai* (d'Orbigny). ×55. (p. 561)
9—*Elphidium discoidale multiloculum* Cushman and Ellisor, n. var. ×38. (p. 561)
10—*Bolivinella subpectinata* Cushman. ×55. (p. 561)
11—*Bolvinella rugosa* Howe. ×55. (p. 561)
12—*Plectofrondicularia mexicana* (Cushman). ×55. (p. 562)
13—*Bulimina pupoides* d'Orbigny. ×42. (p. 562)
14—*Bulimina sculptilis* Cushman. ×55. (p. 562)
15—*Bulimina sculptilis paucicostata* Cushman and Ellisor, n. var. ×55. *a*, Front view- *b*, apertural view. (p. 562)
16—*Bulimina bleeckeri* Hedberg. ×55. (p. 562)



Cushman and Ellisor—Oilgocene Foraminifera



Cushman and Ellisor—Oilgocene Foraminifera

Development Co., Rattlesnake Mound, Brazoria Co., Texas, are very close to, if not identical with, this species.

NODOSARIA SPINICOSTA d'Orbigny
Plate 74, figures 6, 7

Nodosaria spinicosta d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 37, pl. 1, figs. 32, 33.

This species was originally described from the Miocene of the Vienna Basin. The figured specimens from the *Marginulina* zone, from cuttings at 10,220–10,252 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas, are very similar to topotypes of d'Orbigny's species, with which they were compared. In America the species has been recorded from the Alazan clays of Mexico (Cushman, 1927, Jour. Paleontology, vol. 1, p. 154, pl. 24, figs. 5, 6 and Nuttall, 1932, idem, vol. 6, p. 15) and from the Oligocene of Cuba (Palmer and Bermudez, 1936, Soc. cubana hist. nat. Mem., vol. 10, p. 268, pl. 15, fig. 8).

Genus SARACENARIA Defrance, 1824
SARACENARIA cf. S. ACUTAURICULARIS
(Fichtel and Moll)
Plate 74, figure 13

A few specimens from the *Heterostegina* zone, in cuttings from 8660–8691 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas, seem to be close to this apparently widely ranging species. In America it is recorded from Eocene to Miocene.

SARACENARIA SCHENCKI
Cushman and Hobson
Plate 74, figure 12

Saracenaria schencki Cushman and Hobson, 1935, Cushman Lab. Foram. Research Contr., vol, 11, p. 57, pl. 8, fig. 11.—Palmer and Bermudez. 1936, Soc. cubana historia nat. Mem., vol. 10, p. 276.—Kleinpell, 1938, Miocene Stratig. California, p. 222.—Palmer, 1940, Soc. cubana historia nat. Mem., vol. 14, p. 284.—Schenck and Childs, 1942, Stanford Univ. Publ., Univ. Ser. Geol. Sci., vol. 3, no. 2, p. 27 (list).

This species is recorded from the Oligocene and Miocene of California and from the Oligocene of Cuba. Our specimens were compared with the type and seem identical. They are from the *Discorbis* zone, from core at 6702–6797 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas. Similar specimens also occur in the *Heterostegina* zone.

Genus LINGULINA d'Orbigny, 1826
LINGULINA MESONENSIS Cole
Plate 74, figure 10

Lingulina mesonensis Cole, 1930, Bull. Am. Paleontology, vol. 15, no. 57*b*, p. 9, pl. 1, fig. 3.

The figured specimen from the *Discorbis* zone, from cuttings at 8564–8595 feet,

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EXPLANATION OF PLATE 76
(*a*, Front view; *b*, apertural view.)

FIGS. *1*—*Globobulimina hannai* Cushman and Ellisor, n. sp. ×42. (p. 562)
2—*Entosolenia* cf. *E. laevigata* (Reuss). ×55. (p. 563)
3—*Entosolenia crumenata* Cushman. ×55. (p. 563)
4—*Entosolenia* cf. *E. apiculata* (Reuss). ×55. (p. 563)
5—*Bolivina israelskyi* Cushman and Ellisor, n. sp. ×55. (p. 565)
6—*Bolivina davisi* Cushman and Ellisor, n. sp. ×55. (p. 565)
7—*Bolivina gracilis* Cushman and Applin. ×55. (p. 563)
8—*Bolivina tongi* Cushman. ×55. (p. 564)
9—*Bolivina plicatella mera* Cushman and Ponton. ×55. (p. 564)
10—*Uvigerina howei* Garrett. ×55. (p. 566)
11—*Angulogerina byramensis* (Cushman). ×55. (p. 567)
12—*Bitubulogenerina hiwaneensis* Howe. ×55. (p. 565)
13—*Uvigerina lirettensis* Cushman and Ellisor. ×42. (p. 566)
14—*Uvigerina postica* Galloway and Heminway. ×55. (p. 566)
15, 16—*Siphogenerina texana* Cushman and Ellisor, n. sp. ×38. *15*, Holotype, microspheric form. *16*, Paratype, megalospheric form. (p. 566)
17–19—*Ellipsonodosaria verneuili emaciata* Palmer and Bermudez. ×55. (p. 567)

Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, seems identical with this species described from the Oligocene, Meson formation, of Mexico.

Genus FRONDICULARIA Defrance, 1826
FRONDICULARIA ALAZANENSIS Nuttall
Plate 74, figure 11

Frondicularia alazanensis Nuttall, 1932, Jour. Paleontology, vol. 6, p. 17, pl. 3, fig. 15; pl. 4, fig. 1.

The types of this species are from the Oligocene, Alazan shale, of Mexico. The Anahuac specimens, from the *Heterostegina* zone, cuttings at 8688–8718 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, are identical, but are somewhat variable in outline.

Genus LAGENA Walker and Jacob, 1798
LAGENA SULCATA Walker and Jacob

Very rare specimens from the *Heterostegina* zone, in core from 5262–5272 feet, Humble Oil and Refining Co.'s No. 1 Moller, Danbury Field, Brazoria Co., Texas, may be referred to this species. For references, see Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 57, pl. 11, fig. 1.

LAGENA STRIATA SUBSTRIATA Williamson

Lagena substriata Williamson, 1848, Ann. and Mag. and Nat. History ser. 2, vol. 1, p. 15, pl. 1, fig. 12.
Lagena vulgaris substriata Williamson, 1858, Recent Foram. Great Britain, p. 7, pl. 1, fig. 14.
Lagena striata substriata Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 20, pl. 8, figs. 1–3.

Occurring with the preceding species are specimens of a finely costate form which is similar to this variety.

LAGENA COSTATA (Williamson), var
Plate 74, figure 9

A few specimens from the *Discorbis* zone, from cuttings at 6717–6732 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas, one of which is figured, may possibly be the first chambers of a *Nodosaria*. They strongly resemble the proloculum of the form figured by Palm r and Bermudez as "*Nodosaria spinicosta* d'Orbigny" (1936, Soc. cubana historia nat. Mem., vol. 10, p. 268, pl. 15, fig. 8) from the Oligocene of Cuba. A similar form was figured by Cushman and McGlamery from the Oligocene of Alabama (1938, U. S. Geol. Survey, Prof. Paper 189-D, pl. 24, fig. 12).

LAGENA PERLUCIDA (Montagu)

Very rare specimens from the *Heterostegina* zone, from a core at 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas, resemble this species. For references, see Cushman, 1933, U. S. Nat. Mus., Bull. 161, pt. 2, p. 20, pl. 4, figs. 6–8.

Family POLYMORPHINIDAE
Genus GUTTULINA d'Orbigny, 1839
GUTTULINA IRREGULARIS (d'Orbigny)
Plate 74, figure 16

The species ranges from the Eocene to the Miocene and is widely distributed. It occurs in the *Heterostegina* zone, in a core at 7286–7296 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. For references, see Cushman and Applin, 1943, Cushman Lab. Foram. Research Contr., vol. 19, p. 35, pl. 7, fig. 18.

GUTTULINA BYRAMENSIS (Cushman)
Plate 74, figure 15

Polymorphina byramensis Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-E, p. 94, pl. 17, fig. 2. Cushman, 1922, idem, Prof. Paper 129-F, p. 131, idem, 1923, Prof. Paper 133, p. 31, pl. 5, figs. 1–5.

Due to the position of the last-formed chamber in the holotype specimen, this species has been confused with *G. irregularis* (d'Orbigny). In most specimens the chambers reach back to the base but there is an occasional specimen with a final chamber higher up near the aperture. The front view is much more triangular than in *G. irregularis*, and the apertural view also. It seems to be a characteristic species of the American Oligocene. Specimens occur in all three zones of the Anahuac formation. The figured one is from the *Heterostegina* zone in cuttings from 7350–7366 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

Genus GLOBULINA d'Orbigny, 1839
GLOBULINA GIBBA d'Orbigny
Plate 74, figure 17

Specimens which may be referred to this species occur in the *Heterostegina* zone, in

cuttings from 7350–7365 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. They are slightly more globular than the typical form. For references, see Cushman and Applin, 1943, Cushman Lab. Foram. Research Contr. vol. 19, p. 35, pl. 7, fig. 19.

GLOBULINA INAEQUALIS Reuss
Plate 74, figure 18

A few compressed specimens, evidently belonging to this species, are from the *Heterostegina* zone, from cuttings at 8749–8779 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. The species has a wide range. For references, see Cushman and McGlamery, 1942, U. S. Geol. Survey, Prof. Paper 197-B, p. 68, pl. 4, fig. 33.

Genus POLYMORPHINA d'Orbigny, 1826
POLYMORPHINA ADVENA Cushman
Plate 74, figure 20

Polymorphina advena Cushman, 1922, U. S. Geol. Survey, Prof. Paper 129-F, p. 132, pl. 31, fig. 4.—Cushman, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 41, pl. 7, fig. 5.—Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 118, pl. 30, fig. 10.—Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 67, pl. 10, fig. 4.—Cushman, 1935, U. S. Geol. Survey Prof. Paper 181, p. 29, pl. 10, fig. 8.—Cushman and McGlamery, 1938, idem, Prof. Paper 189-D, p. 106, pl. 24, fig. 21.

The known range of this species includes the Miocene, Chipola marl, of Florida, where it is rare; the middle Oligocene of Mississippi and Alabama; and the upper Eocene of South Carolina, Georgia, Alabama, and Mississippi, where it is less typical. Very typical specimens occur in the *Heterostegina* zone, in core at 6822–6827 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

POLYMORPHINA FRONDEA (Cushman)
Plate 74, figure 19

Bolivina frondea Cushman, 1922, U. S. Geol. Survey, Prof. Paper 129-F, p. 126, pl. 29, fig. 3.—Cushman, 1923, idem, Prof. Paper 133, p. 20.
Polymorphina frondea Cushman, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 41.—Cushman and Ozawa, 1930, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 118, pl. 30, fig. 11.—Bermudez, 1938, Soc. cubana historia nat. Mem., vol. 12, p. 20.—Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 68, pl. 5, figs. 5–7.

This is a characteristic species of the middle Oligocene, although Bermudez has recorded it also from the Eocene of Cuba. Typical specimens occur in the *Heterostegina* zone, in core at 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus POLYMORPHINELLA Cushman and Hanzawa, 1936
POLYMORPHINELLA CURTA
Cushman and Ellisor, n. sp.
Plate 74, figure 21

Test small, short, biserial throughout, early portion partially coiled, later uncoiling; chambers few, alternating at the sides of the elongate axis, inflated, increasing rather rapidly in size as added; sutures distinct, slightly depressed; wall smooth; aperture radiate, terminal. Length 0.52–0.60 mm.; breadth 0.30–0.35 mm.; thickness 0.22–0.27 mm.

Holotype (Cushman Coll. 43146) from the *Discorbis* zone of the Anahuac formation, from cuttings at 8566–8597 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

This species differs from *P. vaginulinaeformis* Cushman and Hanzawa in the shorter, thicker test, and much fewer and more inflated chambers. It is the first species of the genus to be recorded from the Oligocene but is the most definitely biserial throughout of any of the few known species.

Genus GLANDULINA d'Orbigny, 1826
GLANDULINA cf. G. LAEVIGATA d'Orbigny
Plate 74, figure 14

A few specimens from the *Heterostegina* zone, from cuttings at 9245–9276 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas, are somewhat less elongate than the typical form of this species but otherwise similar.

Genus RAMULINA Rupert Jones, 1875
RAMULINA cf. R. LAEVIS Jones
Plate 74, figures 22, 23

A few fragmentary specimens referred to this species occur in cuttings from 8597–

8629 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

Family NONIONIDAE
Genus NONION Montfort, 1808
NONION AFFINE (Reuss)
Plate 75, figure 2

(For synonomy, see Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 9.)

This is a common species in the Oligocene of Europe. Our Anahuac specimens have been compared with topotypes and appear to be identical. It has been recorded from the Miocene of America but not previously from the Oligocene. It occurs in the *Heterostegina* zone, in a core at 5507–5517 feet, Humble Oil and Refining Co.'s No. 1 Moller, Danbury Field, Brazoria Co., Texas. It also occurs in the *Discorbis* zone.

NONION ADVENUM (Cushman)
Plate 75, figure 1

(For synonomy, see Cushman and McGlamery, 1942, U. S. Geol. Survey, Prof. Paper 197-B, p. 69.)

This species occurs in the Oligocene and upper Eocene of America. Small but typical specimens occur in the *Heterostegina* zone, core at 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus NONIONELLA Cushman, 1926
NONIONELLA CRASSIPUNCTATA Cushman
Plate 75, figure 3

Nonionella crassipunctata Cushman, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 31, pl. 4, fig. 11.—Palmer, 1940, Soc. cubana historia nat. Mem., vol. 14, p. 289, pl. 51, figs. 3, 4.

This species, described from the Oligocene of Mississippi and recorded from the Oligocene of Cuba, occurs in considerable numbers in the *Heterostegina* zone, in a core at 7356–7366 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

NONIONELLA cf. N. JACKSONENSIS Cushman
Plate 75, figure 6

A number of specimens from the *Discorbis* zone, core at 4591–4609 feet, Humble Oil and Refining Co.'s No. 1 Minnetex, Mykawa Field, Harris Co., Texas, very closely resemble the types of this species. There is a tendency to a deepening of the spiral suture on the dorsal side and the other sutures are slightly deeper and more distinct. In other respects they seem very similar.

NONIONELLA HANTKENI
(Cushman and Applin)
Plate 75, figure 4

Nonionina hantkeni Cushman and Applin, 1926, Am. Assoc. Petroleum Geologists. Bull., vol. 10, p. 182, pl. 10, figs. 10, 11.
Nonionella hantkeni Ellisor, 1933, idem, vol. 17, no. 11, pl. 2, fig. 9.—Cushman, 1935, U. S. Geol. Survey Prof. Paper 181, p. 31, pl. 12, figs. 1, 2.—Cushman, 1939, idem, Prof. Paper 191, p. 30, pl. 8, fig. 4.

The previous American records for this species are from the upper Eocene of Texas and Mexico. The Anahuac specimens have been compared with the types and seem identical. They are from the *Heterostegina* zone in a core at 4416–4422 feet, Humble Oil and Refining Co.'s No. 10 Tabb, Goose Creek, Harris Co., Texas.

NONIONELLA HANTKENI SPISSA Cushman
Plate 75, figure 5

Nonionella hantkeni spissa Cushman, 1931, Cushman Lab. Foram. Research Contr., vol. 7, p. 58, pl. 7, fig. 13.—Ellisor, 1933, Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, pl. 2, figs. 10, 12.—Cushman, 1935, U. S. Geol. Survey, Prof. Paper 181, p. 31, pl. 12, fig. 6.—Cushman and McGlamery, 1938, idem, Prof. Paper 189-D, p. 106, pl. 25, fig. 2.—Cushman, 1939, idem, Prof. Paper 191, p. 30, pl. 8, fig. 5.

This species is known from the upper Eocene and Oligocene of the Southeastern and Gulf Coastal Plain regions of the United States. Rather typical specimens occur in the *Discorbis* zone, in cuttings from 8341–8413 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. It also occurs in the *Heterostegina* zone.

Genus ELPHIDIUM Montfort, 1808
ELPHIDIUM ADVENUM (Cushman)
Plate 75, figure 7

(For synonomy, see Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 60.)

This species has been recorded in the Miocene of Florida and the Tertiary of Cuba, among other records both Recent and fossil. The Anahuac specimens are from a core sample at 2040 feet, Sinclair Oil and Gas Co.'s No. 29 Bryan, Damon Mound, Brazoria Co., Texas.

ELPHIDIUM SAGRAI (d'Orbigny)
Plate 75, figure 8

(For synonomy, see Cushman, 1939, U. S. Geol. Survey, Prof. Paper 191, p. 55.)

There are numerous records for this species from the American Miocene and Oligocene. The Anahuac specimens, although showing some variation, are fairly typical. They are from the *Heterostegina* zone, from a core at 5262–5272 feet, Humble Oil and Refining Co.'s No. 1 Moller, Danbury, Field, Brazoria Co., Texas.

ELPHIDIUM DISCOIDALE MULTILOCULUM
Cushman and Ellisor, n. var.
Plate 75, figure 9

Variety differing from the typical in the larger number of chambers, 14 to 18 in the adult coil, less prominent umbonal region, and more compressed test.

Holotype of variety (Cushman Coll. 43169) from the *Heterostegina* zone of the Anahuac formation, in a core at 4416 feet, Humble Oil and Refining Co.'s No. 10 Tabb, Goose Creek, Harris Co., Texas.

This is probably the same as the form recorded as *E. discoidale* (d'Orbigny) from the Oligocene of Choctaw Bluff, Ala. (Cushman and McGlamery, 1938, U. S. Geol. Survey, Prof. Paper 189-D, p. 106, pl. 25, fig. 3).

Family CAMERINIDAE
Genus OPERCULINOIDES Hanzawa, 1935

OPERCULINOIDES ELLISORAE Gravell and Hanna

Operculinoides ellisorae Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 522, pl. 60, figs. 1–6.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 1, figs. 2, 4, 5.

Operculinoides ellisorae may be distinguished from *Operculinoides howei* Gravell and Hanna in its much flatter test, more rapidly widening whorls, and tendency toward a flange in the last whorls. It occurs in the *Lepidocyclina texana* horizon of the *Heterostegina* zone of the Anahuac formation.

OPERCULINOIDES HOWEI Gravell and Hanna

Operculinoides howei Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 523, pl. 61, figs. 2–6.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 1, figs. 1, 3, 6.

This form is characteristic of the *Lepidocyclina texana* horizon of the *Heterostegina* zone of the Anahuac formation.

Genus HETEROSTEGINA d'Orbigny, 1826

HETEROSTEGINA ISRAELSKYI
Gravell and Hanna

Heterostegina israelskyi Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 524, pl. 62, figs. 1–4.—Gravell and Hanna, 1938, Am. Assoc. Petroleum Geologists Bull., vol. 22, p. 989, pl. 1, figs. 3, 11.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 3, figs. 3–5.

Heterostegina israelskyi differs from the other American species of this genus in its thinner and more fragile test. It occurs in the *Lepidocyclina texana* horizon of the *Heterostegina* zone of the Anahuac.

HETEROSTEGINA TEXANA Gravell and Hanna

Heterostegina texana Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 525, pl. 63, figs. 1–4.—Gravell and Hanna, 1938, Am. Assoc. Petroleum Geologists Bull., vol. 22, p. 989, pl. 1 figs. 4, 5, 10.—Cole, 1938, Florida Geol. Survey Bull. 16, p. 40, pl. 5, figs. 18–21; pl. 6, figs. 1–8.—Cole, 1941, idem, Bull. 19, p. 33, pl. 10, figs. 8, 9; pl. 11, figs. 1, 2.—Cole, 1944, idem, Bull. 26, p. 52, pl. 6, figs. 7–9.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 3, figs. 1, 2, 6.

This is the form that was originally referred to by workers in Texas as "*Heterostegina antillea* Cushman." In *H. texana* the thickened portion of the test is larger than in *H. antillea*, occupying about two-thirds of the diameter of the test, whereas the umbonate portion of *H. antillea* occupies only about one-third of the diameter of the test. The Texas species is smaller than the Cuban one. This is the diagnostic species of the *Heterostegina* zone of the Anahuac.

Family HETEROHELICIDAE
Genus BOLIVINELLA Cushman, 1927

BOLIVINELLA RUGOSA Howe
Plate 75, figure 11

Bolivinella rugosa Howe, 1930, Jour. Paleontology, vol. 4, p. 267, pl. 21, fig. 4.

Compared with paratypes, the Anahuac specimens seem identical. They are from the *Heterostegina* zone, in a core from 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. The types are from the Red Bluff clay of the lower Oligocene.

BOLIVINELLA SUBPECTINATA Cushman
Plate 75, figure 10

Bolivinella subpectinata Cushman, 1929, Cush-

man Lab. Foram. Research Contr., vol. 5, p. 34, pl. 5, fig. 8.—Howe, 1930, Jour. Paleontology, vol. 4, p. 264, pl. 21, fig. 1.

This species is known only from the Byram marl and Red Bluff clay of the middle and lower Oligocene. The Anahuac specimens are from the *Heterostegina* zone in a core at 2040 feet in the Sun Oil Co.'s No. 29 Bryan, Damon Mound, Brazoria Co., Texas.

Genus PLECTOFRONDICULARIA Liebus, 1903

PLECTOFRONDICULARIA MEXICANA
(Cushman)
Plate 75, figure 12

Frondicularia mexicana Cushman, 1926, Cushman Lab. Foram. Research Contr., vol. 1, p. 88, pl. 13, fig. 5.

Plectofrondicularia mexicana Cole, 1927, Bull. Am. Paleontology, vol. 14, no. 51, p. 24.—Nuttall, 1932, Jour. Paleontology, vol. 6, p. 19.—Cushman, 1933, Cushman Lab. Foram. Research, Spec. Publ. no. 4, pl. 21, fig. 13.—Nuttall, 1935, Jour. Paleontology, vol. 9, p. 127, pl. 15, fig. 6.—Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 285.—Bermudez, 1938, idem, vol. 12, p. 19.—LeRoy, 1939, Nat. Tijdscher Nederl.-Indie, vol. 99, p. 241, pl. 7, figs. 11, 12.—Cushman, 1940, Foraminifera, 3rd ed., pl. 21, fig. 13.

This species is known from the Oligocene and Eocene of Mexico and Cuba, and from the Eocene of Venezuela, and is recorded from the Miocene of Central Sumatra. The Anahuac specimens are typical. They are from the *Marginulina* zone, in a core at 10,200–10,210 feet in the Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA PUPOIDES d'Orbigny
Plate 75, figure 13

Bulimina pupoides d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 185, pl. 11, figs. 11, 12.

This is a very variable species with a fairly long range, apparently from Eocene to Recent. The Anahuac specimens are from the *Heterostegina* zone, from cuttings from 8937–8967 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

BULIMINA SCULPTILIS Cushman
Plate 75, figure 14

Bulimina sculptilis Cushman, 1923, U. S. Geol. Survey Prof. Paper 133, p. 23, pl. 3, fig. 3.—Cushman and Schenck, 1928, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, p. 311, pl. 43, fig. 16.—Cole and Ponton, 1930, Florida Geol. Survey Bull. 5, p. 38, pl. 9, fig. 11.—Nuttall, 1932, Jour. Paleontology, vol. 6, p. 19, pl. 5, fig. 1.—Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 286.—Cushman and Parker, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 37, pl. 4, fig. 3.—Franklin, 1944, Jour. Paleontology, vol. 18, p. 314, pl. 45, fig. 15.

This is typically an Oligocene species, widely distributed, particularly in the middle Oligocene. It is recorded from the Gulf Coastal Plain region, Oregon, Mexico, Cuba, and Venezuela. Typical specimens occur in the *Marginulina* zone, in a core from 7392–7397 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

BULIMINA SCULPTILIS PAUCICOSTATA
Cushman and Ellisor, n. var.
Plate 75, figure 15

Variety differing from the typical in the very slender test and fewer costae.

Holotype of variety (Cushman Coll. 43182) from the *Marginulina* zone of the Anahuac formation in a core from 7500–7505 feet, in Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Jefferson Co., Texas.

BULIMINA BLEECKERI Hedberg
Plate 75, figure 16

Bulimina bleeckeri Hedberg, 1937, Jour. Paleontology, vol. 11, p. 675, pl. 91, figs. 12, 13.—Palmer, 1940, Soc. cubana historia nat. Mem., vol. 14, p. 295.—Franklin, 1944, Jour. Paleontology, vol. 18, p. 314, pl. 46, fig. 14.

This species was recorded from the Oligocene of Venezuela and Cuba. Similar specimens occur in the *Marginulina* zone, from a core at 7392–7397 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA HANNAI
Cushman and Ellisor, n. sp.
Plate 76, figure 1

Test broadest at the base and narrowing toward the apertural end; chambers distinct, strongly inflated, in the megalospheric form with three chambers visible on one side and

two on the opposite side, the miscrospheric form slightly narrower and with one or more additional chambers visible; sutures distinct, depressed; wall smooth, thin, finely perforate; aperture loop-shaped with a fairly high apertural tooth. Length 0.62–0.72 mm.; breadth 0.37–0.50 mm.

Holotype (Cushman Coll. 43186) from the *Marginulina* zone of the Anahuac formation, in a core at 7392–7397 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas. It also occurs in the *Heterostegina* zone, in cuttings from 8937–8967 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

The species differs from *G. pacifica* Cushman in the smaller size, relatively much broader test at the base, and deeper sutures. Specimens referred to *G. pacifica* from the Oligocene of Cuba and Venezuela may belong to *G. hannai*. The species is named in honor of Dr. Marcus A. Hanna.

Genus ENTOSOLENIA Ehrenberg, 1848

ENTOSOLENIA cf. E. LAEVIGATA (Reuss)
Plate 76, figure 2

This species has been widely recorded from Recent to Paleocene. Our Anahuac specimens are the same as those figured under this name from the Oligocene, Chickasawhay marl, near Millry, Ala. (Cushman and McGlamery, 1942, U. S. Geol. Survey, Prof. Paper 197-B, p. 70, pl. 5, figs. 19–21). They are from the *Heterostegina* zone, core at 7356–7366 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

ENTOSOLENIA CRUMENATA Cushman
Plate 76, figure 3

Entosolenia crumenata Cushman, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 31, pl. 4, fig. 9.—Cushman and McGlamery, 1938, U. S. Geol. Survey Prof. Paper 189-D, p. 109, pl. 26, fig. 11.—Cushman, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 66, pl. 11, figs. 4, 5.—Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 70, pl. 5, figs. 16–18.—Cushman and Todd, 1942, Cushman Lab. Foram. Research Contr., vol. 18, p. 37, pl. 6, fig. 28.—Cushman, 1944, idem, vol. 20, p. 43, pl. 7, fig. 12.

This species is known from Alabama and Mississippi and apparently ranges from the Paleocene to the middle Oligocene. Specimens are rare in the *Heterostegina* zone, in a core at 5608–5630 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

ENTOSOLENIA cf. E. APICULATA (Reuss)
Plate 76, figure 4

A few specimens with one, or usually two, short basal spines may be referred to this species. They are from the *Heterostegina* zone and occur with the preceding species.

ENTOSOLENIA cf. E. HEXAGONA Williamson

A very few specimens with hexagonal surface ornamentation may be referred here. They are from a core at 5674–5688 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA EXILIS Cushman and Ellisor

Virgulina exilis Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 6, pl. 1, fig. 11.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 3.; 1944, idem, vol. 28, no. 9, pl. 7, fig. 3.

This species occurs in all three zones of the Anahuac. It differs from *Virgulina colei* Cushman from the Oliogocene of Mexico, which it somewhat resembles, in the more slender form and in the larger number of biserial chambers, which are much more regular in the adult than those of the Mexican Oligocene species.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA GRACILIS Cushman and Applin
Plate 76, figure 7

Bolivina gracilis Cushman and Applin, 1926, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 167, pl. 7, figs. 1, 2.—Cole, 1927, Bull. Am. Paleontology, vol. 14, no. 51, p. 26, pl. 5, fig. 13.—Howe and Wallace, 1932, Louisiana Geol. Survey Bull. 2, p. 57.—Cushman, 1935, U. S. Geol. Survey Prof. Paper 181, p. 37, pl. 14, figs. 8–10; 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 9, p. 59, pl. 7, figs. 22, 23.—Cushman and McGlamery, 1938, U. S. Geol. Survey Prof. Paper 189-D, p. 108, pl. 26, figs. 1, 2.—Cushman and McGlamery, 1942, idem, Prof. Paper 197-B, p. 71.

This species is known from the upper Eocene of the Gulf Coastal Plain and Mexico and recorded from the middle Oligocene of Alabama. Our Anahuac specimens have been compared with the types and appear to be identical. They are from the *Discorbis*

zone, in a core at 6702–6707 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

BOLIVINA PLICATELLA MERA
Cushman and Ponton
Plate 76, figure 9

Bolivina plicatella mera Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 82, pl. 12, fig. 4.—Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 9, p. 90, pl. 11, figs. 5–8. —Cushman and McGlamery, 1938, U. S. Geol. Survey Prof. Paper 189-D, p. 108.

This variety, described from the Miocene of Florida, occurs also in the Oligocene of Choctaw Bluff, Ala. It occurs in fairly typical form in the *Heterostegina* zone, in a core from 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. It also is present in the *Discorbis* zone.

BOLIVINA cf. B. PAULA Cushman and Cahill

A very few specimens related to this species occur in the same sample as the preceding. The species is known from the Miocene and Oligocene.

BOLIVINA TENUISTRIATA
Cushman and Ellisor

Bolivina tenuistriata Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 5, pl. 1, fig. 8.—Ellisor, 1940, Am. Assoc. Petroleum Geol. Bull., vol. 24, no. 3, pl. 1, fig. 2.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 7, fig. 2.

This species differs from *Bolivina cookei* Cushman from the middle Oligocene of Alabama and Mississippi in the more elongate form, much finer ornamentation, and more oblique sutures. At the present time it has been found only in the *Discorbis* zone of the Anahuac formation.

BOLIVINA PERCA Garrett

Bolivina perca Garrett, 1938, Jour. Paleontology, vol. 12, p. 315, pl. 40, figs. 8–10.—Ellisor, 1944, Am. Assoc. Petroleum Geol. Bull., vol. 28, no. 9, pl. 7, figs. 10–12.

This species occurs in both the *Heterostegina* and *Marginulina* zones. There is variation in the number and coarseness of the punctations so that the surface details vary in different specimens. The peripheral keel also varies considerably.

BOLIVINA GLADIUS Garrett

Bolivina gladius Garrett, 1942, Jour. Paleontology, vol. 16, p. 462, pl. 70, fig. 8.

Typical specimens occur in the *Heterostegina* zone in a core at 6826–6857 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field. Jefferson Co., Texas.

BOLIVINA TONGI Cushman
Plate 76, figure 8

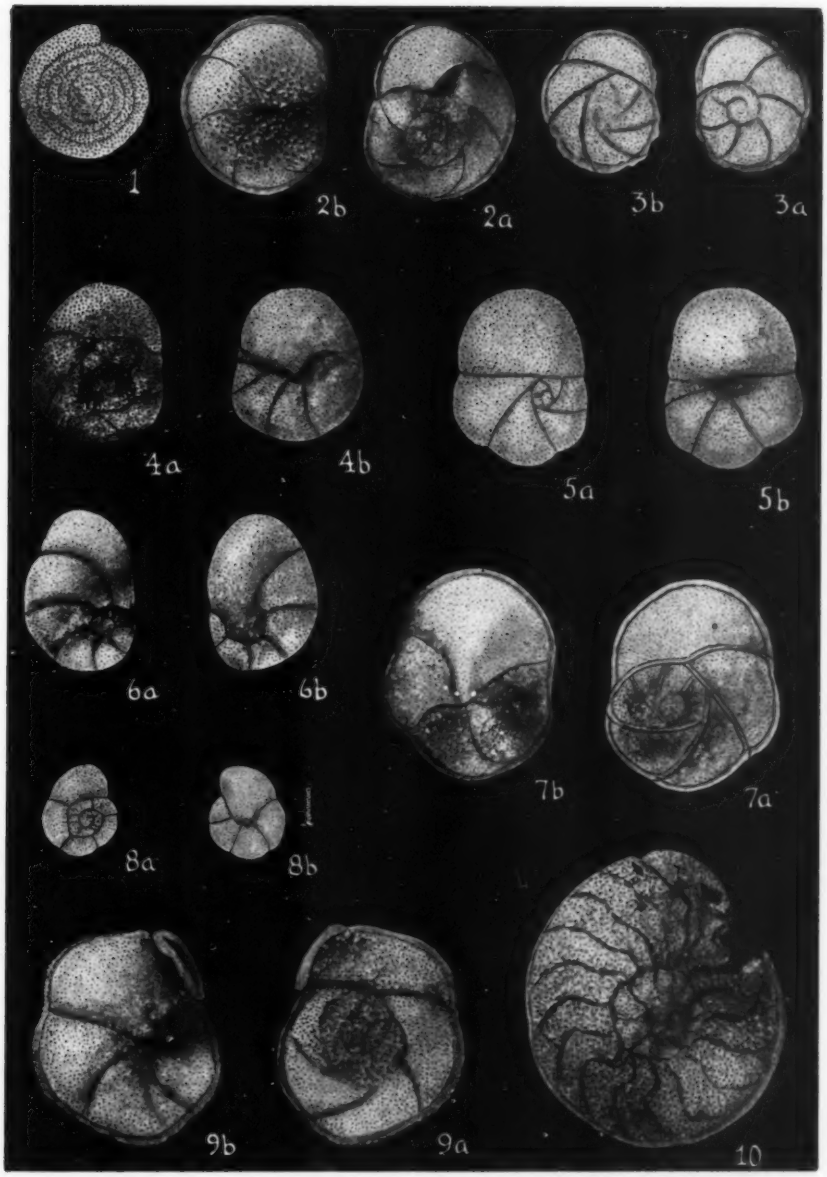
Bolivina tongi Cushman, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 93, pl. 13, fig. 29.—Nuttall, 1932, Jour. Paleontology, vol. 6, p. 21, pl. 5, fig. 4.—Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 290.—Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 9, p. 92, pl. 12, figs. 7, 8.—Palmer, 1940, Soc. cubana historia nat. Mem., vol. 14, p. 300.

This species was described from the Tertiary of Venezuela and is known from the Oligocene of Mexico and Cuba. Specimens closely related to it occur in the *Marginulina* zone in a core at 7500–7505 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

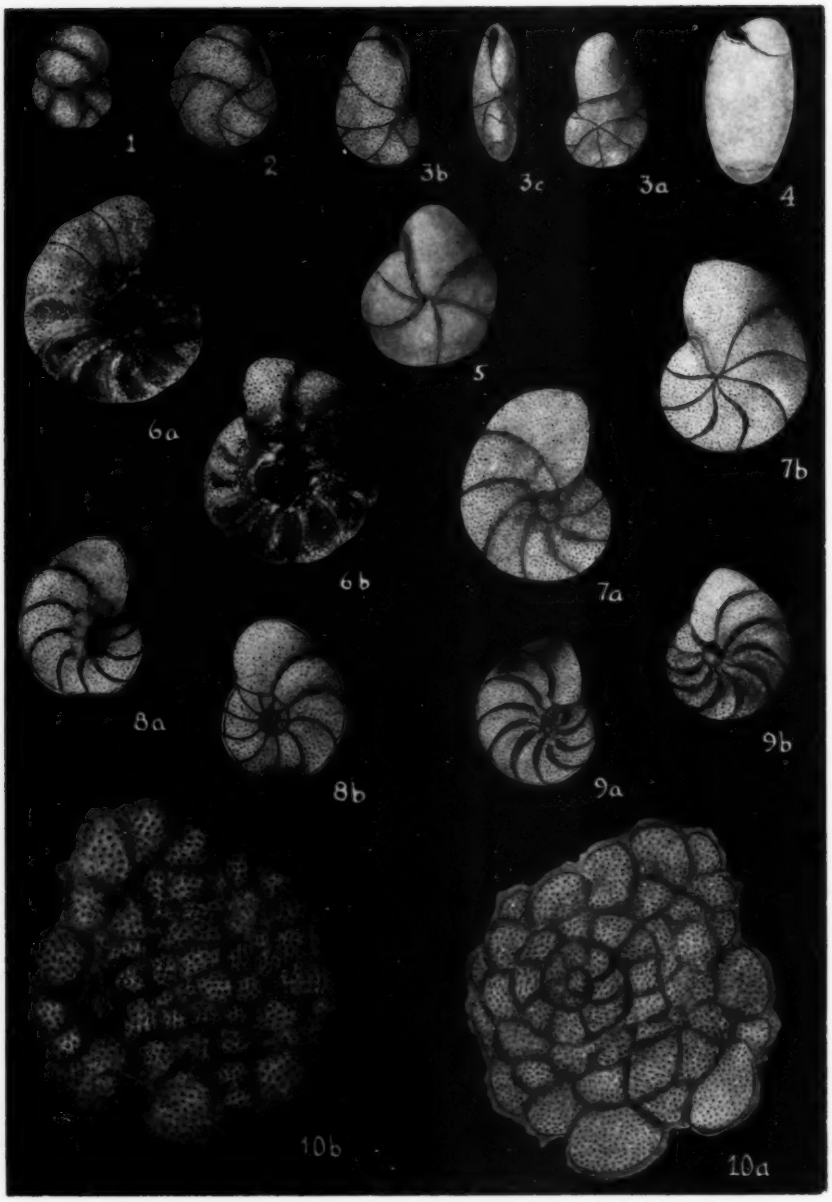
EXPLANATION OF PLATE 77

(*a*, Dorsal view; *b*, ventral view.)

FIGS. *1*—*Spirillina* cf. *S. vivipara* Ehrenberg. ×55. (p. 567)
2—*Discorbis subpatelliformis* Cushman and McGlamery. ×55. (p. 567)
3—*Discorbis* sp. ×55. (p. 568)
4, 5—*Valvulineria paucilocula* Cushman. ×55. (p. 568)
6—*Valvulineria georgiana* Cushman. ×38. (p. 568)
7—*Eponides repandus oligocenicus* Cushman and Ellisor, n. var. ×38. (p. 569)
8—*Gyroidina danvillensis* Howe and Wallace. ×55. (p. 568)
9—*Siphonina advena anahuacana* Cushman and Ellisor, n. var. ×55. (p. 569)
10—*Amphistegina chipolensis grandis* Cushman and Ellisor, n. var. ×38. (p. 569)



Cushman and Ellisor—Oilgocene Foraminifera



Cushman and Ellisor—Oilgocene Foraminifera

BOLIVINA DAVISI Cushman and Ellisor, n. sp.
Plate 76, figure 6

Test broadly rhomboid in front view, nearly twice as long as broad, strongly compressed, thickest along the median line, periphery slightly keeled; chambers distinct, increasing gradually in size as added; sutures strongly limbate, somewhat raised, especially in the earlier stages, strongly curved, last-formed ones often slightly depressed; wall finely but distinctly perforate, the sutures of the early portion raised, as is also the median line, with usually a single vertical short ridge near the median line of each chamber; aperture narrow, elongate. Length 0.45–0.67 mm.; breadth 0.25–0.30 mm.; thickness 0.09–0.10 mm

Holotype (Cushman Coll. 43204) from the *Discorbis* zone of the Anahuac formation in cuttings at 8566–8597 feet, in the Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

This species remsembles *B. byramensis* Cushman, but lacks the reticulate pattern of ornamentation and is more broadly rhomboid. It also somewhat resembles *B. alazanensis* Cushman, but that species is unornamented.

The species is named in honor of Mr. Morgan J. Davis with whose permission this paper is published.

BOLIVINA ISRAELSKYI
Cushman and Ellisor, n. sp.
Plate 76, figure 5

Test elongate, about 2½ times as long as broad, gradually tapering, periphery serrate, chambers distinct, numerous, increasing rather rapidly in height in the adult portion, very slightly inflated, sutures slightly limbate, flush with the surface, earlier ones nearly at right angles to the elongate axis, gradually becoming strongly oblique in the adult portion; wall smooth; aperture elongate, narrow. Length 0.55–0.65 mm.; breadth 0.22–0.27 mm.; thickness 0.10 mm.

Holotype (Cushman Coll. 43206) from the *Heterostegina* zone of the Anahuac formation, in cuttings from 8660–8691 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

This species differs from *Bolivina perca* Garrett in the more rapid rate of expansion of the test toward the apertural end and in the decided change in the angle of the sutures from young to adult stages. The species is named in honor of Mr. Merle C. Israelsky.

Genus BIFARINA Parker and Jones, 1872
BIFARINA VICKSBURGENSIS MONSOURI
Garrett

Bifarina vicksburgensis monsouri Garrett, 1939, Jour. Paleontology, vol. 13, p. 577, pl. 65, fig. 14.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, fig. 14.

This variety differs from the typical form in being less compressed and in having a less developed biserial portion and a better developed uniserial portion. It is present in all three zones.

Genus BITUBULOGENERINA Howe, 1934
BITUBULOGENERINA HIWANNEENSIS Howe
Plate 76, figure 12

Bitubulogenerina hiwanneensis Howe, 1934, Jour. Paleontology, vol. 8, p. 421, pl. 51, fig. 2.—

EXPLANATION OF PLATE 78

(*a*, Dorsal view; *b*, ventral view.)

FIGS. *1*—*Cassidulina chipolensis* Cushman and Ponton. ×55. (p. 570)
2—*Cassidulina galvinensis* Cushman and Frizzell. ×55. (p. 570)
3—*Cassidulinoides compacta* Cushman and Ellisor, n. sp. ×55. *c*, Peripheral view. (p. 570)
4—*Chilostomella oolina* Schwager. ×55. (p. 570)
5—*Pullenia salisburyi* R. E. and K. C. Stewart. ×55. (p. 570)
6—*Anomalina bilateralis anahuacana* Cushman and Ellisor, n. var. ×38. (p. 571)
7—*Cibicides americanus* (Cushman). ×55. (p. 571)
8—*Cibicides concentricus texana* Cushman and Ellisor, n. var. ×55. (p. 571)
9—*Cibicides isidroensis* Cushman and Renz. ×55. (p. 571)
10—*Planorbulinella larvata* (Parker and Jones). ×55. (p. 572)

Cushman, 1937, Cushman Lab. Foram. Research, Spec. Publ. no. 9, p. 211, pl. 24, figs. 7, 8.

The only records for this species are from the Red Bluff clay member of the lower Oligocene of Mississippi The Anahuac specimens evidently belong to this species, and occur in the *Heterostegina* zone, in cuttings from 8718–8749 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA LIRETTENSIS Cushman and Ellisor

Plate 76, figure 13

Uvigerina lirettensis Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 7, pl. 1, fig. 13.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 2, fig. 6.—Cushman and Todd, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 49, pl. 14, figs. 10, 11.

Specimens from the Anahuac, *Marginulina* zone, are identical with this species described from the Miocene of Louisiana. They are also very much like *U. carapitana* Hedberg, described from the upper Oligocene of Venezuela and recorded from the Oligocene of Cuba and the Miocene and Oligocene of Trinidad. Our specimens are from core samples at 7605–7610 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

UVIGERINA PILULATA Cushman and Ellisor

Uvigerina pilulata Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 7, pl. 1, fig. 12.—Ellisor, 1940, Am. Assoc Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 4.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 7, fig. 4.

So far as known this distinctive species occurs only in the *Discorbis* zone.

UVIGERINA ISRAELSKYI Garrett

Uvigerina israelskyi Garrett, 1939, Jour. Paleontology, vol. 13, p. 577, pl. 65, figs. 15, 16.—Cushman and Todd, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 48, pl. 12, figs. 10, 11; pl. 14, fig. 7.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 15, 16.

This species differs from *Uvigerina vicksburgensis* Cushman and Ellisor in having fewer and continuous longitudinal costae, and in the character of the sutures which are irregular and deeply depressed. This form is found in all three zones of the Anahuac formation.

UVIGERINA HOWEI Garrett

Plate 76, figure 10

Uvigerina howei Garrett, 1939, Jour. Paleontology, vol. 13, p. 577, pl. 65, figs. 13, 17.—Cushman and Todd, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 47, pl. 12, figs. 2, 3; pl. 13, figs. 18–22.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 5, figs. 13, 17.

Specimens from the *Heterostegina* zone of the Anahuac formation seem identical with this species described from the *Discorbis* zone of the Anahuac in Jefferson Co., Texas. Our specimens often have the later chambers becoming somewhat hispid as noted by Garrett. They are from cuttings fron 9153–9183 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

UVIGERINA POSTICA Galloway and Heminway

Plate 76, figure 14

Uvigerina postica Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 431, pl. 33, figs. 3, 4.

Abundant specimens in the *Marginulina* zone seem identical with this species from the upper Oligocene, Cibao formation, of Puerto Rico. They are from a core at 7685–7695 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

Genus SIPHOGENERINA Schlumberger, 1883

SIPHOGENERINA TEXANA Cushman and Ellisor, n. sp.

Plate 76, figures 15, 16

Test elongate, about 3 times as long as broad, the later portion uniserial; chambers distinct, somewhat inflated, becoming irregularly biserial and then the last one or two uniserial in the adult; sutures distinct, slightly depressed; wall ornamented with a few, usually 12, longitudinal costae, continuous over the sutures, rather high and

platelike; aperture terminal, with a short neck and phialine lip. Length 1.20–1.45 mm.; diameter 0.40–0.48 mm.

Holotype (Cushman Coll. 43218) from the *Discorbis* zone of the Anahuac formation, in cuttings from 8566–8597 feet in the Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas.

This species differs from *S. nodifera* Cushman and Kleinpell in the higher and thinner costae and more distinct chambers. Our specimens, in some characters, suggest a relationship with *Uvigerina israelskyi* Garrett, but are much larger and definitely belong in *Siphogenerina*.

SIPHOGENERINA FREDSMITHI Garrett

Siphogenerina fredsmithi Garrett, 1939, Jour. Paleontology, vol. 13, p. 577, pl. 66, fig. 1.—Ellisor, 1944, Am. Assoc. Petroleum Geologists, Bull., vol. 28, no. 9, pl. 6, fig. 1.

This distinctive species has been observed only in the *Discorbis* zone.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA BYRAMENSIS (Cushman)
Plate 76, figure 11

Uvigerina byramensis Cushman, 1922, U. S. Geol. Survey Prof. Paper 129-E, p. 95, pl. 18, fig. 5.—Cushman, 1922, idem, Prof. Paper 129-F, p. 133; 1923, Prof. Paper 133, p. 34, pl. 4, figs. 10, 11.—Applin, 1925, Am. Assoc. Petroleum Geologist Bull., vol. 9, p. 25.—Howe, 1928, Jour. Paleontology, vol. 2, p. 175 (list).—Cole and Ponton, 1930, Florida Geol. Survey Bull. 5, p. 39, pl. 9, fig. 7.—Cole and Gillespie, 1930, Bull. Am. Paleontology, vol. 15, no. 57*b*, p. 11, pl. 2, fig. 6.

Angulogerina byramensis Ellisor, 1933, Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, pl. 3, fig. 16.—Cushman and McGlamery, 1938, U. S. Geol. Survey Prof. Paper 189-D, p. 109, pl. 26, figs. 9, 10.—Cushman and Edwards, 1938, Cushman Lab. Foram. Research Contr., vol. 14, p. 87, pl. 15, figs. 18, 19.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 6.—Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 72, pl. 6, figs. 4–10.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 7, fig. 6.

This is a characteristic species of the American Oligocene. There is some variation, in any large series, in the ornamentation and the looseness of arrangement of the later chambers. It occurs in all three of the zones. The figured specimen is one of a series from the *Heterostegina* zone, in a core from 6867–6872 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

Family ELLIPSOIDINIDAE
Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA VERNEUILI EMACIATA
Palmer and Bermudez
Plate 76, figures 17–19

Ellipsonodosaria verneuili (d'Orbigny), var. Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 295, pl. 18, figs. 14–16.

Ellipsonodosaria verneuili (d'Orbigny), var. *emaciata* Palmer and Bermudez, in Palmer, 1941, idem, vol. 15, p. 189.

This variety, described from the Oligocene of Cuba, is present in typical form in our Anahuac material, in the *Marginulina* zone in a core from 10,449–10,459 feet, Humble Oil and Refining Co.'s No. 2-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Family ROTALIIDAE
Genus SPIRILLINA Ehrenberg, 1843
SPIRILLINA cf. S. VIVIPARA Ehrenberg
Plate 77, figure 1

This species is recorded as ranging from Jurassic to Recent. A number of specimens referable to it occur in the *Heterostegina* zone, in a core from 5608–5630 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus DISCORBIS Lamarck, 1804
DISCORBIS SUBPATELLIFORMIS Cushman and McGlamery
Plate 77, figure 2

Discorbis subpatelliformis Cushman and McGlamery, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 48, pl. 9, fig. 8; 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 72, pl. 6, fig. 16.

This species was described from the Oligocene of Alabama. Specimens from the *Heterostegina* zone seem identical. They are from a core from 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

DISCORBIS SUBARAUCANA DISSONA Cushman and Ellisor

Discorbis subaraucana dissona Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 10, pl. 2, fig. 2.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 9.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 7, fig. 9.

This variety is very close to if not identical with the form figured as "*Discorbis subaraucana*" from the Oligocene of Millry, Ala. (Cushman and McGlamery, 1942, U. S. Geol. Survey, Prof. Paper 197-B, pl. 6. fig. 17). The species has a wide stratigraphic range as it is also present in the Fleming as well as in the Anahuac formation.

DISCORBIS GRAVELLI Garrett

Discorbis gravelli Garrett, 1939, Jour. Paleontology, vol. 13, p. 578, pl. 66, figs. 2, 3.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, figs. 2, 3.

This form occurs abundantly in all three zones of the Anahuac formation.

DISCORBIS NOMADA Garrett

Discorbis nomada Garrett, 1939, Jour. Paleontology, vol. 13, p. 578, pl. 66, fig. 4.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, fig. 4.

This species is characteristic of the *Discorbis* zone.

DISCORBIS sp.
Plate 77, figure 3

A few specimens from the *Heterostegina* zone in No. 1 Woodburn at 5630–5652 feet are possibly the young stages of some larger species. They are figured so that they may be available for future reference.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA PAUCILOCULA Cushman
Plate 77, figures 4, 5

Valvulineria paucilocula Cushman, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 37, pl. 5, fig. 7.—Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 371, pl. 16, fig. 4.—Cushman and McGlamery, 1942, U. S. Geol. Survey Prof. Paper 197-B, p. 73, pl. 6, fig. 19.

Typical specimens of this Oligocene species occur in the *Heterostegina* zone, in a core from 2040 feet, Sinclair Oil and Gas Co.'s No. 29 Bryan, Damon Mound, Brazoria Co., Texas. With the typical form is another slightly more involute and with higher chambers (pl. 77, fig. 5). It is from the same sample.

VALVULINERIA GEORGIANA Cushman
Plate 77, figure 6

Valvulineria georgiana Cushman, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 82, pl. 12, fig. 17.—Cushman, 1936, Geol. Soc. America Bull., vol. 47, p. 424, pl. 3, fig. 3.

The Anahuac specimens show some variation but appear to belong to this species rather than to *V. nuttalli* Palmer and Bermudez from the Oligocene of Cuba. Our specimens are from the *Heterostegina* zone, in cuttings from 9061–9092 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas. Somewhat similar specimens occur in the *Heterostegina* zone, in cuttings from 8877–8909 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas. In some respects the specimens resemble *Cancris*, but lack the clear area on the ventral side, and the apertural characters are those of *Valvulineria*.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA DANVILLENSIS Howe and Wallace
Plate 77, figure 8

Gyroidina danvillensis Howe and Wallace, 1932, Louisiana Dept. Cons., Geol. Bull. 2, p. 69, pl. 13, fig. 3.—Nuttall, 1935, Jour. Paleontology, vol. 9, p. 128, pl. 15, figs. 10, 11.

A number of very small specimens seem nearer to this species than to any other. The size and most of the other characters are the same. It is probably the same as that referred to *Gyroidina* sp. by Cushman and McGlamery (1942, U. S. Geol. Survey, Prof. Paper 197-B, p. 73, pl. 6, fig. 20) from the Oligocene of Alabama. Our specimens are from the *Heterostegina* zone, in a core from 5262–5272 feet, Humble Oil and Refining Co.'s No. 1 Moller, Danbury Field, Brazoria Co., Texas. Similar forms also occur in the *Discorbis* zone.

GYROIDINA VICKSBURGENSIS HANNAI Garrett

Gyroidina vicksburgensis hannai Garrett, 1939, Jour. Paleontology, vol. 13, p. 578, pl. 66, fig. 5.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, fig. 5.

This form is more compressed than the Vicksburg species. It occurs abundantly in the *Discorbis* and *Heterostegina* zones.

Genus EPONIDES Montfort, 1808

EPONIDES REPANDUS OLIGOCENICUS Cushman and Ellisor, n. var.

Plate 77, figure 7

Variety differing from the typical in the fewer and broader chambers and less prominent sutures.

Holotype of variety (Cushman Coll. 43239) from the *Heterostegina* zone of the Anahuac formation, in a core from 7356–7366 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

EPONIDES ELLISORAE Garrett

Eponides ellisorae Garrett, 1939, Jour. Paleontology, vol. 13, p. 579, pl. 66, figs. 6–8.—Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 372, pl. 17, fig. 4.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, figs. 6–8.

This variable form occurs in all three zones.

EPONIDES ORNATISSIMUS Galloway and Heminway

Eponides ornatissimus Galloway and Heminway, 1941, New York Acad. Sci., Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 373, pl. 17, fig. 2.

Specimens apparently identical with this species occur in the *Heterostegina* zone, in a core from 5674–5688 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus SIPHONINA Reuss, 1850

SIPHONINA ADVENA ANAHUACANA Cushman and Ellisor, n. var.

Plate 77, figure 9

Variety differing from the typical in the more distinctly plano-convex form, the dorsal side being practically flat, usually with a wide serrate flange; and in the aperture which is elongate, less projecting, and with the opening distinctly ventral.

Holotype of variety (Cushman Coll. 43241) from the *Marginulina* zone of the Anahuac formation, in a core from 7685–7695 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

SIPHONINA DAVISI Cushman and Ellisor

Siphonnia davisi Cushman and Ellisor, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 10, pl. 2, fig. 3.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 1, fig. 5.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 7, fig. 5.

This species has not been found, as far as known, below the *Discorbis* zone.

Family AMPHISTEGINIDAE

Genus ASTERIGERINA d'Orbigny, 1839

ASTERIGERINA BRACTEATA Cushman

Asterigerina bracteata Cushman, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 48, pl. 8, fig. 6.—Cushman and McGlamery, 1938, U. S. Geol. Survey Prof. Paper 189-D, p. 111, pl. 28, fig. 3.—Cushman and McGlamery, 1942, idem, Prof. Paper 197-B, p. 74.

This is a characteristic species of the Oligocene of Alabama and Mississippi. Typical specimens occur in the *Heterostegina* zone, in a core from 5630–5652 feet, Humble Oil and Refining Co.'s No. 1 Woodburn, Genoa Field, Harris Co., Texas.

Genus AMPHISTEGINA d'Orbigny, 1826

AMPHISTEGINA CHIPOLENSIS GRANDIS Cushman and Ellisor, n. var.

Plate 77, figure 10

Variety differing from the typical in the larger size and more umbonate test with a tendency to have the chambers shorter on the dorsal side and failing to reach the umbo. The chambers are also more numerous than in the typical form.

Holotype of variety (Cushman Coll. 43245) from the *Heterostegina* zone of the Anahuac formation, in cuttings from 7366–7376 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

Family CASSIDULINIDAE
Genus CASSIDULINA d'Orbigny, 1826
CASSIDULINA CHIPOLENSIS Cushman and Ponton
Plate 78, figure 1

Cassidulina chipolensis Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 98, pl. 15, fig. 2.

Typical specimens of this species occur in the *Heterostegina* zone, in a core from 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. It also occurs in the *Discorbis* zone.

CASSIDULINA GALVINENSIS Cushman and Frizzell
Plate 78, figure 2

Cassidulina galvinensis Cushman and Frizzell, 1940, Cushman Lab. Foram. Research Contr., vol. 16, p. 43, pl. 8, fig. 10.—Cushman and Frizzell, 1943, idem, vol. 19, p. 87, pl. 15, fig. 6.

Our specimens were compared with the type of this species, described from the Oligocene of Washington. The size is slightly smaller but otherwise they are much alike. They are from the *Heterostegina* zone, in a core from 4773–4791 feet, Humble Oil and Refining Co.'s No. 1 Minnetex, Mykawa Field, Harris Co., Texas. It also occurs in the *Discorbis* zone.

Genus CASSIDULINOIDES Cushman, 1927
CASSIDULINOIDES COMPACTA Cushman and Ellisor, n. sp.
Plate 78, figure 3

Cassidulinoides bradyi Cushman (not Norman), 1930, Florida Geol. Survey Bull. 4, p. 58, pl. 11, fig. 8.—Cushman and Ponton, 1932, idem, Bull 9, p. 98.—Cusman and Cahill, 1933, U. S. Geol. Survey Prof. Paper 175-A, p. 33, pl. 12, fig. 4.—Palmer and Bermudez, 1936, Soc. cubana historia nat. Mem., vol. 10, p. 306.—Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, no. 3, pl. 6, fig. 5.—Palmer, 1941, Soc. cubana historia nat. Mem., vol. 15, p. 283.

Test longer than broad, compressed, close-coiled for most of its development, but the last two chambers tending to uncoil, periphery rounded; chambers distinct, moderately inflated, increasing rapidly in length in the adult; sutures distinct, slightly if at all depressed; wall smooth; aperture somewhat longer than broad, in the adult near the periphery. Length 0.25–0.30 mm.; breadth 0.15–0.20 mm.; thickness 0.12–0.15 mm.

Holotype (Cushman Coll. 43252) from the *Heterostegina* zone of the Anahuac formation, in cuttings from 8749–8779 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

This species differs from *C. bradyi* (Norman) in the more compact test, less elongate and more compressed chambers, and the less amount of uncoiling. It has been recorded from the Miocene and Oligocene of the Gulf Coastal Plain of the United States and Cuba.

Family CHILOSTOMELLIDAE
Genus CHILOSTOMELLA Reuss, 1850
CHILOSTOMELLA OOLINA Schwager
Plate 78, figure 4

Chilostomella oolina Schwager, 1878, R. Com. Geol. Italia Boll., vol. 9, p. 527, pl. 1, fig. 16.

A few small specimens seem to be related to, if not identical with, this species. It has been recorded in related formations from the Miocene of Florida and the Oligocene of Venezuela. The specimens are elongate and the aperture very narrow. They are from the *Heterostegina* zone, in a core from 6822–6827 feet, Shell Oil Co., and Humble Oil and Refining Co.'s No. 2 McFadden, Clam Lake Field, Jefferson Co., Texas.

Genus PULLENIA Parker and Jones, 1862
PULLENIA SALISBURYI R. E. and K. C. Stewart
Plate 78, figure 5

Pullenia salisburyi R. E. and K. C. Stewart, 1930, Jour. Paleontology, vol. 4, p. 72, pl. 8, fig. 2.—Cushman and Moyer, 1930, Cushman Lab. Foram. Research Contr., vol. 6, p. 61, pl. 8, fig. 13.—Cushman and Parker, 1931, idem, vol. 7, p. 15, pl. 2, fig. 15.—Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, p. 117, pl. 14, fig. 2.—Cushman, 1933, Cushman Lab. Foram. Research Spec. Publ. no. 5, pl. 33, fig. 18.—Cushman and Todd, 1943, Cushman Lab. Foram. Research Contr., vol. 19, p. 20, pl. 3, figs. 10, 11.—Beck, 1943, Jour. Paleontology, vol. 17, p. 609, pl. 108, figs. 8, 12.—Cushman and Frizzell, 1943, Cushman Lab. Foram. Research Contr., vol. 19, p. 88, pl. 14, fig. 16.

Specimens from the Anahuac formation have been compared with the types of this species from the Pliocene of California and seem to be identical. The above references

seem to be to this species, although there are others which, from the figures, are evidently different. The specimens average six chambers in the adult whorl. Our specimens are from the *Heterostegina* zone, in cuttings from 9245–9276 feet, Humble Oil and Refining Co.'s No. 1-B Houston Farms Development Co., Halls Bayou, Brazoria Co., Texas.

Family GLOBIGERINIDAE

There are a number of species of *Globigerina* in the Anahuac fauna, but this group is now being studied and is in too chaotic a state to warrant giving names to these at present.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA BILATERALIS ANAHUACANA Cushman and Ellisor, n. var.

Plate 78, figure 6

Variety differing from the typical in the larger size, the more open coiling showing the earlier chambers on both sides, the umbonal boss on the dorsal side more prominent, and the sutures more strongly limbate.

Holotype of variety (Cushman Coll. 43256) from the *Marginulina* zone of the Anahuac formation, in cuttings from 9644–9675 feet, Humble Oil and Refining Co.'s No. 4 Houston Farms Development Co., Brazoria Co., Texas.

This variety is very close to the typical form from the Vicksburg but the two can be distinguished when seen together.

Genus CIBICIDES Montfort, 1808

CIBICIDES AMERICANUS (Cushman)

Plate 78, figure 7

No references for this species are given as the name has been widely applied and the forms need much study. Typical specimens occur in the *Heterostegina* zone, in a core from 7346–7356 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas.

CIBICIDES CONCENTRICUS TEXANA Cushman and Ellisor, n. var.

Plate 78, figure 8

Variety differing from the typical in the smaller size, and in the more compressed and somewhat evolute test, having the earlier whorls visible on the ventral side.

Holotype of variety (Cushman Coll. 43257) from the *Heterostegina* zone of the Anahuac formation, from cuttings at 8660–8691 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas. This is a distinctive form related to *C. concentricus*, but the inner secondary band of material is narrower and not as well developed as in the typical form.

CIBICIDES ISIDROENSIS Cushman and Renz

Plate 78, figure 9

Cibicides isidroensis Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 26, pl. 4, fig. 10.—Renz, 1942, 8th Am. Sci. Congress Proc., p. 556 (list).

This species, described from the lowermost to upper Miocene, Agua Salada formation, of Venezuela, has also been recorded from the lower middle Miocene, Brasso formation, of Trinidad. Somewhat smaller but otherwise identical specimens occur abundantly in the *Marginulina* zone, in a core from 7685–7695 feet, Sun Oil Co.'s No. 1 Hamilton, Chambers Co., Texas. It also occurs less abundantly in the *Heterostegina* and *Discorbis* zones.

CIBICIDES MOREYI Garrett

Cibicides moreyi Garrett, 1939, Jour. Paleontology, vol. 13, p. 579, pl. 66, fig. 9.—Ellisor, 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, fig. 9.

Specimens from the *Heterostegina* zone, from cuttings at 8660–8691 feet, Humble Oil and Refining Co.'s No. 3 Houston Farms Development Co., Rattlesnake Mound, Brazoria Co., Texas, have been compared with metatypes of this species and seem identical.

CIBICIDES JEFFERSONENSIS Garrett

Cibicides jeffersonensis Garrett, 1939, Jour. Paleontology, vol. 13, p. 579, pl. 66, fig. 10.—Ellisor 1944, Am. Assoc. Petroleum Geologists Bull., vol. 28, no. 9, pl. 6, fig. 10.

This species was described from the *Discorbis* zone of the Anahuac.

CIBICIDES cf. C. LOBATULUS (Walker and Jacob)

There are a number of specimens in the Anahuac formation which may be compared to this species. It is difficult to give specific names as there is so much confusion in this group. It is hoped that studies now under way of type and typotype material will straighten out many of the questions in regard to these variable forms.

Family PLANORBULINIDAE
Genus PLANORBULINELLA Cushman, 1927
PLANORBULINELLA LARVATA (Parker and Jones)
Plate 78, figure 10

This form in the Anahuac formation is similar to those recorded from the Oligocene of the Coastal Plain region of the United States and from Cuba. The figured specimen is from the *Heterostegina* zone, in a core from 4412–4417 feet, West Production Co.'s No. 1 Lobit, Harris Co., Texas.

MANUSCRIPT RECEIVED MARCH 6, 1945.

Family ORBITOIDIDAE
Genus LEPIDOCYCLINA Gümbel, 1870
LEPIDOCYCLINA (LEPIDOCYCLINA) COLEI Gravell and Hanna

Lepidocyclina (*Lepidocyclina*) *colei* Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 526, pl. 61, fig. 1; pl. 63, fig. 5; pl. 64, figs. 1–6. —Gravell and Hanna, 1938, Am. Assoc. Petroleum Geologists Bull., vol. 22, p. 990.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 2, figs. 2, 3, 6.

This species is characteristic of the *Lepidocyclina texana* horizon of the *Heterostegina* zone of the Anahuac formation.

LEPIDOCYCLINA (LEPIDOCYCLINA) TEXANA Gravell and Hanna

Lepidocyclina (*Lepidocyclina*) *texana* Gravell and Hanna, 1937, Jour. Paleontology, vol. 11, p. 527, pl. 65, figs. 1–7.—Gravell and Hanna, 1938, Am. Assoc. Petroleum Geologists Bull., vol. 22, p. 994.—Ellisor, 1944, idem, vol. 28, no. 9, pl. 2, figs. 1, 4, 5.

This species is diagnostic of the *Lepidocyclina* horizon of the *Heterostegina* zone of the Anahuac formation.

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SOME NEW GENERA OF PALEOZOIC GASTROPODA[1]

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ABSTRACT—Twelve new genera and seven new species of Paleozoic Gastropoda are erected. Eight of these new genera are referred to the superfamily Pleurotomariacea; *Ananias*, genotype *Phanerotrema? welleri* Newell; *Spiroscala*, genotype *S. pagoda* Knight, n. sp.; *Dictyotomaria*, genotype *Pleurotomaria scitula* Meek and Worthen; *Glyptotomaria*, genotype *G. apiarium* Knight, n. sp.; *Callistadia*, genotype *C. bella* Knight, n. sp.; *Platyzona*, genotype, *Pleurotomaria trilineata* Hall; *Portlockiella*, genotype *P. kentuckyensis* Knight, n. sp.; and *Crenilunula*, genotype *Pleurotomaria limata* Lindström. Three genera are referred to the Trochonematacea; *Amaurotoma*, genotype *Pleurotomaria subsinuata* Meek and Worthen; *Cinclidonema*, genotype *C. texanum* Knight, n. sp.; and *Micromphalus*, genotype *M. turris* Knight, n. sp. One genus is referred to the Omphalotrochacea (new); *Orecopia*, genotype *Platyschisma? mccoyi* Walcott. A new species, *Ananias whitei* Knight, is erected for *Pleurotomaria grayvillensis* White, 1880, not. *P. grayvillensis* Norwood and Pratten, 1855.

RECENTLY it was found advisable to publish a paper on some new genera of the Bellerophontacea (Knight, 1945) in order to avoid labelling specimens in the U. S. National Museum with names not validated by publication. As the work on the Paleozoic Gastropoda in the Museum progressed beyond the Bellerophontacea, specimens of species of certain other undescribed and unnamed genera were met with. The purpose of the present paper is to validate the names of these genera through publication. The work on the collections of Paleozoic gastropoda is by no means completed but circumstances have temporarily called a halt to it. When the work is resumed it is probable that still other new genera will be needed.

Since knowledge of the gastropods of the Paleozoic has not yet advanced to the point where satisfactory family assignments can be made for many genera, superfamily assignments must suffice for the present.

I am indebted to Dr. G. Arthur Cooper of the U. S. National Museum for all photographs except those of *Callistadia bella* on Plate 1.

Superfamily PLEUROTOMARIACEA

Genus ANANIAS Knight, n. gen.

Pleurotomaria (in part) of Geinitz, 1866 (p. 9), and of Meek, 1872 (p. 231).
Phanerotrema (in part) of White 1880 (p. 140), of Girty, 1909 (p. 96), and of Newell, 1935 (p. 347).
?Worthenia (in part) of Plummer and Moore, 1921 (expl. pl. 19).

Genotype, *Phanerotrema? welleri* Newell, 1935, (p. 348).

Diagnosis.—Somewhat turreted, turbiniform pleurotomarians with the straight, or very gently concave upper whorl-surface sloping outward at an angle of about 45° from the vertical to the prominently carinate periphery, a concave outer whorl-face below the periphery and a flatly rounded base below a more or less obscure angulation that separates it from the outer whorl-face; a concave lunulate selenizone occupying the periphery, its lower margin protruding very slightly more than the upper, the selenizone slightly above the middle of the final whorl and well above the angular, but shallow sutures on the earlier whorls; base rather flatly rounded below the more or less obscure angulation that separates it from the concave outer whorl-face above, and anomphalous or minutely phaneromphalous; slit narrow, seemingly about ⅛ whorl circumference in depth; the sinus in the outer lip broad and shallow, with the obliquity of margin both above and below the periphery not very strong except close to the selenizone; columellar lip very little thickened and reflexed; parietal inductura thin; ornamentation consisting of both revolving and transverse elements, often with nodes where they cross, the revolving elements dominating on the base and the transverse close to the upper suture.

[1] Published with the permission of the Secretary of the Smithsonian Institution.

Comparisons.—*Ananias* differs from *Bembexia* Oehlert, 1888, most conspicuously in its more tabulated, more angular, whorls and its more turreted spire. It also shows a concave outer whorl-face set off from the flatly rounded base by an angulation. Two species of *Ananias* in the American Pennsylvanian converge so strikingly on species of other genera abundantly represented in the same beds that their appearance is most deceiving. *A. welleri*, for example, so closely mimics *Worthenia tabulata* (Conrad) in form and ornamentation that it is commonly found in collections misidentified as that species and some reports of *W. tabulata* in published fossil lists are probably based on it. *W. tabulata*, of course, has the convex, crenulated selenizone that serves to distinguish *Worthenia* from all genera with a concave selenizone. *A. wannense* (Newell) 1935, on the other hand, has a lower, less turreted spire and somewhat resembles the abundant species of *Glabrocingulum* of the American Pennsylvanian, such as *G. grayvillense* (Norwood and Pratten). *Ananias* is to be differentiated from *Glabrocingulum* by its relatively more turreted spire, which is evident on even the earlier whorls, and by the more elevated carina occupied by the selenizone. Another species in the American Pennsylvanian referable to *Ananias* is *Pleurotomaria marcouiana* Geinitz, 1866. There is likewise an undescribed species from the Smithwick shale of Texas, and four species in the Permian of the southwest, two of them as yet undescribed. One species was described and figured by White, 1880 (p. 140, pl. 34, fig. 5a) as *Pleurotomaria grayvillensis* Norwood and Pratten. Needless to say this is not *P. grayvillensis* and I propose the name, *A. whitei* Knight, for it. *A. whitei* was collected by G. K. Gilbert from a locality then known as the Wild Band Pockets in northern Arizona in a region now known to be underlain by the Permian Kaibab limestone. The holotype and paratype of *A. whitei* are in the U. S. National Museum under USNM 24527. Another species referable to *Ananias* is *Phanerotrema manzanicum* Girty, 1909, from Permian Yeso and Abo formations, of New Mexico.

Range.—Pennsylvanian-Permian.

Genus SPIROSCALA Knight, n. gen.

Pleurotomaria (*Murchisonia?*) (in part) of Hall, 1858 (p. 21), of Meek and Worthen, 1867 (p. 271) and of Girty, 1934 (p. 254).
Neilsonia (in part) of Thomas, 1939 (p. 46).

Genotype, *Spiroscala pagoda* Knight, n. sp.

Diagnosis.—Acutely conical, trochiform pleurotomarians with a flat or flatly rounded, narrowly or minutely phaneromphalous base, and rather strongly protruding flange like carinae bordering the selenizone; the selenizone lying just above the angular periphery bordered above and below by conspicuous flanges that in some species are rather thick, with revolving lirae on their inner sides, in which species the selenizone is narrow and concave, and that in others are less thick and without lirae on their inner sides, in which species the selenizone is wider and may be convex; slit seemingly somewhat deep; pleural angle of the shell about 50° and the upper whorl-face conforming in general with the slope of the shell; just below the lower carina of the selenizone a somewhat acute angulation, in some species separated from the lower carina by a groove, the angulation forming the periphery and the outer limit of the flat or flatly rounded base; the flattened base turning sharply into the narrow umbilicus; ornamentation of the upper whorl-face dominantly transverse but in some species with fine revolving lirae as well, on the base very fine transverse lirae and fine revolving lirae, the differences between the two whorl-faces very marked in this respect.

Comparisons.—In its conical form and flattish base *Spiroscala* suggests *Euconospira* Ulrich in Ulrich and Scofield, 1897, to which it is probably related. It may be differentiated from *Euconospira* almost at a glance by its relatively heavy flange like carinae, its stronger ornamentation and its usually open, if narrow, umbilicus. On the other hand *Spiroscala* shows some resemblances to *Neilsonia* Thomas, 1939. However *Neilsonia*, as here restricted, comprises less elevated shells with a more protruding, anomphalous base. *Neilsonia* also lacks the revolving elements in its ornamentation and has a broader, always concave selenizone.

I would refer to *Spiroscala*, besides the genotype, the American species *Pleurotomaria conula* Hall, 1858, from the Salem Limestone, Mississippian, and *Pleurotomaria conoides* Meek and Worthen, 1867 (equals *P. coniformis* Worthen, 1881) from Pennsylvanian rocks of late Des Moines age in Illinois; also *P. rockymontana* Girty, 1934, from the Pennsylvanian McCoy formation of Colorado. There is furthermore an undescribed species with a convex selenizone from the same horizon and locality as the genotype and another undescribed species occurs in Graham shale of the Cisco group, Pennsylvanian, in McCulloch Co. Texas.

Still another undescribed species is found in the Permian, Bone Spring limestone in the Sierra Diablo north of Van Horn, Texas. Although I shall not discuss European species in general, it may be of service to say that *Neilsonia acuminata* Thomas, 1939, seems to be referable to *Spiroscala*.

Range.—Mississippian—Lower Permian.

SPIROSCALA PAGODA Knight, n. sp.
Plate 79, figures 5a–b

Description.—Sides of the spire very slightly concave; base strongly flattened, bordered by an acute, subcarinate angulation, with a narrow umbilicus; whorls about 12 in number, the height about one-fourth the width on the later whorls; profile of the upper whorl-surface convex in its upper half, concave as the upper carina of the selenizone is approached; a sharp, narrow groove between the lower carina of the selenizone and the peripheral angulation around the flattened base; the selenizone very narrow, concave, bordered and seemingly restricted by notably thick carinae, each of which bears on its inner slope two revolving lirae, as though the basically rather wide slit were reduced in width in two stages by accretions from each side before it was completely closed by the forward growth of the selenizone from its inward end; columellar lip seemingly straight, reflexed about the umbilicus; ornamentation, on the upper whorl-face moderately strong transverse lirae, stronger and less oblique backwards on the upper, convex half of the whorl-face and finer, more numerous and with increasingly strong obliquity on the lower half, and moderately strong revolving lirae which, again, are stronger above and weaker to the vanishing point below, in the groove between the lower carina and the basal angulation, fine transverse lirae, and on the base fine revolving lirae crossed by faint growth-lines only; shell moderately thick, its structure unknown.

Dimensions.—With allowance for breakage.

	No. of whorls	Pleural angle	Height	Width
Holotype. Plummer Coll. P-4341	12	52°	11.8 mm.	8.5 mm.
Paratype. Plummer Coll. P-14064	11	50°	12.4 mm.	8.7 mm.

Remarks.—The species is represented by two excellent specimens with surface characters beautifully preserved. The apex is missing on both specimens and the final half whorl is broken away. The depth of the slit cannot be observed but it was certainly less than half the whorl circumference.

Comparisons.—*S. pagoda* is about twice as large as *S. conula* (Hall) and is much more coarsely ornamented. The revolving elements of the onamentation of *S. conula* are wanting although one revolving lira is present on the inner side of each of the carinae bordering the selenizone. I hesitate to compare *S. pagoda* in detail to *S. coniformis* (Worthen) since the descriptions and, particularly, the figures of that species are inadequate. I have no specimens. However, it may be safely said that *S. pagoda* is a larger, coarser shell. *S. rockymontana* (Girty) seems to have a much smaller pleural angle, around 30° to 35°. I shall not compare *S. pagoda* with European species nor with the undescribed American species with which I am familiar. However, it is interesting to note that the other species occurring in the same beds as *S. pagoda* at the same locality differs from it notably in several particulars and, most strikingly, in that the carinae bordering the selenizone are not thickened within and the unrestricted selenizone is consequently wide and, surprisingly, somewhat convex.

Hypodigm.[1]—The two specimens listed below.

Occurrence.—Two specimens in the F. B. Plummer collection at the Bureau of Economic Geology, University of Texas, Austin, Texas. The holotype bears the number P-4341 and the paratype P-14064. Both specimens were collected from the Keechi Creek shale, of the Whitt Group, Canyon Series, Pennsylvanian System, at Bureau of Economic Geology locality 181-T-43. This locality is ¼ to ½ mile west and north of Union Hill School, 6 miles north-northwest of Mineral Wells, Texas.

Genus DICTYOTOMARIA Knight, n. gen.

Pleurotomaria (in part) of Hall, 1858 (p. 21), Meek and Worthen 1861 (p. 461), and 1866 (p. 351).
Ptychomphalus (in part) of Sayre, 1930 (p. 134).
Orestes? (in part) of Girty, 1934 (p. 255).

Genotype, *Pleurotomaria scitula* Meek and Worthen, 1861 (p. 461).

Diagnosis.—Small, low, sub-trochiform pleurotomarians, with a flatly rounded base, upper whorl-face rounded, in some species slightly shouldered close to the upper suture, becoming nearly vertical just above the upper carina of the selenizone; the outer whorl-face below the lower carina of the selenizone narrow, of approximately the same width as the selenizone, separated from the flatly rounded base by a rounded angulation; a rather broad, depressed selenizone with sharp bordering carinae and sharp lunulae occupying the nearly vertical outer whorl-face somewhat below the middle of the final whorl and falling somewhat above the angular, but shallow, sutures on the earlier whorls; sinus in the outer lip shallow; columellar lip straight, slightly thickened, reflexed about the narrow umbilicus; ornamentation above the selenizone even, sharp revolving and transverse lirae crossing each other to form a net-work and forming only obscure nodes at their intersections, below the selenizone the revolving lirae dominate, especially on the base although the transverse elements are also present, especially between the lower carina of the selenizone and the basal angulation.

Comparisons.—*Dictyotomaria* needs comparison with *Phymatopleura* Girty, 1939, for it is that genus that it resembles most closely. Perhaps the most useful distinction is that the vertical outer whorl-face below the selenizone is wider in *Dictyotomaria* than in *Phymatopleura;* in other words the selenizone in *Dictyotomaria* lies in the middle of a nearly vertical outer whorl-face while in *Phymatopleura* the upper whorl-face slopes to the upper margin of the selenizone and the outer whorl-face below the band is much narrower. *Borestus* Thomas, 1939 also has a selenizone in the middle of a distinct outer whorl-face but in this genus the outer whorl-face is broader and distinctly concave between two sharp angulations. The spire in *Borestus* is also markedly turreted. In some respects, *Glyptotomaria* (new) seems most closely related to *Dictyotomaria* but is readily distinguished by its high, conical spire and low, flat whorls without impressed sutures.

Besides the genotype I refer to *Dictyotomaria, Pleurotomaria meekana* Hall, 1858, from the Salem limestone of Mississippian age at Spergen, Indiana, *Ptychomphalus lineata* Sayre, 1930 from the Pennsylvanian Westerville oölite at Kansas City, Missouri, and both *Orestes? reticulatus* Girty, 1934 and *Orstes? quadrilineatus* Girty, 1934 from the Pennsylvanian McCoy formation at McCoy, Colorado. What is seemingly an undescribed species from the Keechi Creek shale of the Whitt group, Canyon Series, Pennsylvanian at the Union Hill School locality, northwest of Mineral Wells, Texas, is also represented in the National Museum collections.

Range.—Mississippian-Pennsylvanian.

DICTYOTOMARIA SCITULA (Meek and Worthen) 1861
Plate 79, figures 3a, b

I shall not redescribe this species here nor attempt its synonymy. However the species has not been adequately figured heretofore and it seems advisable to take advantage of this opportunity to illustrate it photographically. The specimen illustrated is from the top of the Labette shale, Des Moines Series, Pennsylvanian, at Locality 43 of Knight, 1933a (p. 177) in St. Louis County, Missouri. It has been deposited in the U. S. National Museum (no. 111780). It

[1] Simpson, G. G., 1940, Types in Modern Taxonomy; Am. Jour. Sci., Vol. 238, p. 417.

has been compared with specimens from the St. David limestone at Hodges Creek, Macoupin County, Illinois, Meek and Worthen's type locality. The St. Louis County specimen is illustrated rather than one of those from the type locality because its preservation is better and it is more suitable for the purpose. The St. David limestone of Illinois and the Labette shale of Missouri are not far apart in the stratigraphic section.

Genus GLYPTOTOMARIA Knight, n. gen.

Genotype, *Glyptotomaria apiarium* Knight, n. sp.

Diagnosis.—Conical, trochiform pleurotomarians with slightly convex sides and a flat, anomphalous base; whorls low and wide; the outer whorl-surface above the cord-like basal angle conforming closely to the general surface of the sides of the spire with only shallow, angular sutures separating the outer whorl-faces of succeeding whorls; selenizone impressed below the general surface, and passing around the whorls about one-third the distance between sutures above the lower suture, with strong, even lunulae; outer lip with shallow sinus; columellar lip straight, reflexed; ornamentation above the selenizone revolving and transverse lirae that cross without forming conspicuous nodes, below the selenizone finer revolving lirae and, on the cord-like basal angulation fine transverse lirae, fine transverse lirae dominant.

Comparison.—*Glyptotomaria* is very close to *Dictyotomaria* (new) in respect to the details of its ornamentation and the characters of its selenizone. It is to be differentiated from *Dictyotomaria* by its narrowly conical, bee-hive-like form, shallow sutures, and whorl-faces conforming closely to the sides of the spire. No species, other than the genotype, is known.

Range.—Pennsylvanian.

GLYPTOTOMARIA APIARIUM Knight, n. sp.
Plate 79, figures 4a-c

Description.—With the characters of the genus. Ornamentation above the selenizone two or three revolving lirae, the upper one double and forming a conspicuous band a little below the upper suture, crossed by evenly spaced transverse lirae following the course of the outer lip and crossing the revolving lirae, below the selenizone from four to six fine revolving lirae on the cord-like basal angulation separated from the lower carina of the selenizone by a narrow groove showing only strongly oblique transverse lirae which turn quickly to cross the basal angulation, on the base fine revolving lirae crossed by growth-lines or very fine transverse lirae, shell moderately thick, seemingly composed of two distinct layers.

Dimensions.—(Estimated with allowance for breakage.)

	Number of whorls	Pleural angle	Height	Width
Holotype (AMNH 26083)	10	25°	12.3 mm.	8.5 mm.
Paratype	9	30°	8.1 mm.	5.6 mm.

Remarks.—The holotype and paratypes are, for the most part, beautifully preserved from a calcareous shale matrix.

Comparisons.—Since this is the only known species of the genus comparisons with other species are impossible.

Hypodigm.—Six specimens as listed below.

Occurrence.—Four specimens from the Keechi Creek shale, Whitt Group, Canyon Series, Pennsylvanian System at an exposure ¼ mile west and north of Union Hill School, 6 miles NNW of Mineral Wells, Texas, one, the holotype, in the American Museum of Natural History, New York, under number 26083, two in the National Museum under USNM 111765, and one in the University of Texas, Bureau of Economic Geology collection under number K-999; one specimen in the National Museum, USNM 111764, from the Gonzales formation, Graham Group, Cisco Series, Pennsylvanian, collected at the roadside 3.9 miles N.W. of Finis, Young County, Texas, and another, USNM 27162 recorded simply from the Cisco Series at Graham, Texas.

Genus CALLISTADIA Knight, n. gen.
Turbonellina (in part) of C. Wanner, 1922 (p. 33).

Genotype, *Calistadia bella* Knight, n. sp.

Diagnosis.—Turbiniform pleurotomarians with relatively low spire, revolving orna-

mentation, and a short, broad slit just above the nearly vertical outer whorl-face generating a broad, concave selenizone, sloping strongly inward above, rather high on the whorl; whorl-face above the selenizone narrow, convex, and sloping gently downward to the upper margin of the selenizone, below the selenizone, nearly vertical and straight or very gently concave and joining the base roundly; base flatly rounded, narrowly phaneromphalous; outer lip with a shallow sinus culminating at the slit; columellar lip thin, the upper part convex toward the umbilicus, the lower part sloping obliquely away from the umbilicus; ornamentation revolving lirae or costae alone covering the entire surface, often including the selenizone, transverse elements lacking and even the growth lines few and faint so that the lunulae of the selenizone are difficult to discover; shell moderately thin, its structure unknown.

Comparisons.—In some respects *Callistadia* most closely resembles *Glabrocingulum* Thomas, 1939, the most obvious differences being its broader selenizone often ornamented by revolving lirae and its lack of the transverse ornamentation that is so strongly developed in that genus. Although two species of *Callistadia*, *C. concinna* (C. Wanner), specimens of which are in the National Museum collection, USNM 92237, and *C. nitida* (C. Wanner) were referred to *Turbonellina* de Koninck, 1881, the reference is grossly erroneous as may be seen readily by studying the characters of the genotype, *T. lepida* (de Koninck), 1843, as redescribed by Knight, 1941 (p. 372). *Turbonellina* is not a pleurotomarian genus and has no slit or selenizone, but a rounded sinus low on the whorl. It also differs in other respects too numerous and obvious to mention. Wanner did not note the selenizone on his species, probably because the lunulae are exceedingly faint, but careful examination of the National Museum specimens discloses the lunulae.

Besides the genotype and the two species described by C. Wanner from the Permian of Timor, there is another undescribed species in the Bone Spring limestone, Permian, of the Sierra Diablo, north of Van Horn, Texas, and a specimen of another in the U. S. National Museum collections (USNM 99078, part) from what are probably Permian beds 5 miles north of Prospect Valley, Yavapai County, Arizona.

CALLISTADIA BELLA Knight, n. sp.
Plate 79, figures 1a–e

Description.—This species characterized by relatively few, rather strong, revolving costae, a single major costa above the selenizone, with a few fine lirae in the wide concave interspaces, the selenizone bordered by costae very similar to the one above it, occasionally with a fine lira between them, the nearly vertical outer whorl face with a single costa, somewhat less strong than the others, passing around it slightly below its middle, the base with 10 or 12 costae more closely spaced than those above.

Dimensions.—(Estimated with allowance for breakage.)

	Number of whorls	Pleural angle	Height	Width
Holotype	7	75°	11 mm.	12.7 mm.

Remarks.—The specimens of this species are silicifications etched from the limestone matrix with acid. Except that the initial whorl is missing and the outer lip somewhat broken the holotype shows the characters of the species very well.

Comparisons.—The revolving elements on *C. bella* are more widely spaced than on either of the two species described by Wanner or in the two undescribed species from the American Permian mentioned above.

Hypodigm.—Four specimens, one of them a juvenile.

Occurrence.—The holotype and the juvenile paratype were collected from a lens of gray limestone, interbedded with the black calcareous siltstone about 100 feet above the base of the Bone Spring limestone, Leonardian Series, Permian, exposed on the second hillock to the north on the lower shoulder of the north portal of Apache Canyon, Sierra Diablo, Hudspeth County, Texas. These specimens are in the Princeton University collections and have not yet been assigned catalogue numbers. Two paratypes,

also as yet uncatalogued, are in the collections of the U. S. National Museum, one from the upper part of the Leonard formation, Permian, at Split Tank, in the Glass Mountains, and the other from limestone No. 1 of the Word formation, Permian, on the Word Ranch, in the Glass Mountains, Brewster County, Texas.

Genus PLATYZONA Knight, n. gen.

Helix? (in part) J. Sowerby, 1817 (p. 160).
Pleurotomaria (in part) of de Koninck, 1843 (p. 376), of Hall, 1858 (p. 21) and numerous other authors.
Mourlonia (in part) of de Koninck, 1883 (p. 75).

Genotype, *Pleurotomaria trilineata* Hall, 1858 (p. 25).

Diagnosis.—Turbiniform pleurotomarians with rounded whorls, deep sutures, and a broad, flat selenizone passing around the whorls slightly below the middle of the final whorl and clearly above the lower suture on the earlier whorls; margin of the outer lip with a narrow sinus culminating in a seemingly very short, broad, notch like slit that generates the selenizone, columellar lip thin, reflexed about the umbilicus; base rounded or somewhat flattened, narrowly phaneromphalous; ornamentation dominantly revolving lirae above and below the selenizone, faint transverse growth lines alone on the selenizone.

Comparison.—*Platyzona* is to be distinguised from *Shansiella* Yin, 1932, (equals *Latischisma* Thomas, 1939) by the higher spire, deeper sutures, wider, flatter selenizone, and phaneromphalous base in the former. It resembles much more closely *Pithodea* de Koninck, 1881, and its name may ultimately fall into the synonymy of *Pithodea*. Nevertheless it appears to represent a distinct phyletic line of closely related species. *Pithodea*, as known from its genotype, has a very thin shell, its revolving ornamentation consists of plicae rather than lirae, its whorls are less inflated and relatively higher, its sutures shallower, and its base is more extended and anomphalous. *Gyrodoma* Etheredge, 1898, has a narrower selenizone and, seemingly, an anomphalous base.

Platyzona is represented in the American Pennsylvanian by *Pleurotomaria broadheadi* White, 1880 (p. 169) and several undescribed species distributed throughout the system. A species from the European lower Carboniferous is *Helix? cirriformis* Sowerby, 1817 referred by de Koninck, 1883 (p. 95) to *Mourlonia*. A specimen in the U. S. National Museum (no. 63251) recorded from the Rhenish middle Devonian at Paffrath, Germany, identified as *Pleurotomaria subcarinata* Römer, is clearly referable to *Platyzona*. If this specimen is correctly labeled it carries the genus down to the middle Devonian.

Range.—Devonian?, Mississippian—Pennsylvanian.

Genus PORTLOCKIELLA Knight, n. gen.

Turbo (in part) of de Koninck, 1843 (p. 452).
Portlockia (in part) of de Koninck, 1881 (p. 81), not *Portlockia* McCoy, 1846.
?Ptychomphalus (in part) of Weller, 1916 (p. 253).
Yunnania (in part) of Knight, 1933b (p. 38), of Wenz, 1938 (p. 229), and of Knight in Shimer and Shrock, 1944 (p. 451).

Genotype, *Portlockiella kentuckyensis* Knight, n. sp.

Diagnosis.—Relatively low spired, turbiniform pleurotomarians with somewhat inflated whorls and a very shallow, notch-like slit low on the whorls that gives rise to a selenizone; whorls typically rounded, the lower ones embracing the upper ones up to or above the selenizone; in some species somewhat shouldered and flattened on the outer whorl face due to stronger development of the two costae bordering the outer whorl face; sutures rather shallow; outer lip oblique backward down to the shallow, notch-like slit that generates the selenizone, below the selenizone, at first vertical for a very short distance and then oblique backwards into the umbilicus; columellar lip only slightly thickened, reflexed about the umbilicus; parietal inductura thin; base rounded, minutely phaneromphalous; ornamentation dominantly revolving, usually rather strong, sharp, revolving costae, usually with concave interspaces, and transverse lirae, much weaker than the revolving costae; the selenizone similar to the interspaces of the costae and recognizable principally by its lunulae which are concave toward the aperture, and somewhat asymmetrical.

Comparison and discussion.—Some years ago (Knight, 1933b, p. 38), I pointed out that the name *Portlockia* de Koninck, 1881, was a junior homonym of *Portlockia* McCoy,

1846 and was therefore invalid. I then suggested that *Yunnania* Mansuy, 1912, was a valid and available junior subjective synonym and that there was no need to replace *Portlockia* de Koninck with a new name. Following my suggestion *Yunnania* was employed as synonymous with *Portlockia* by Wenz 1938 (p. 229), by Knight, 1941 (p. 269) and by others. During the present study I have had occasion to examine fairly numerous specimens of several closely related species, including topotype specimens of *Turbo pygmaeus* de Koninck, 1843, genotype of *Portlockia* de Koninck, in the National Museum and the Yale University collections, and I am convinced that my earlier interpretations of the characters of *Turbo pygmaeus* was erroneous and that this species is not congeneric with *Yunnania termieri* Mansuy, genotype of *Yunnania*. I was led astray by the difficulty of interpreting the characters of the outer lip of *Turbo pygmaeus*, difficulties occasioned by the extremely weak development of the growth lines and transverse elements in the ornamentation, on which one must so often place reliance for determining the characters of the margin of the outer lip, augmented by the preservation of the specimens, which is such that it tends to obscure details of the finest kind. The key to the correct interpretation of the outer lip of the genus I am dealing with was furnished by *Portlockiella kentuckyensis* (new), a species very similar in essentials to *Turbo pygmaeus* de Koninck, except that the growth lines are expressed as clear-cut, sharp and easily visible lirae. These show that in this species the concave band, or interspace as I then called it, at which the course of the growth lines change, is a true lunulate selenizone and not, as I described it in 1941 (p. 269) for *T. pygmaeus*, merely the locus of the apex of a sinus. It is true that the slit, if so it may be called, that generates the selenizone is hardly more than a notch in the outer lip, but the notch is sharply limited and any attempt to distinguish between a "slit" and a sharp, though shallow, "notch" by the use of such strongly contrasting terms, is over-emphasizing differences in depth alone, in what is essentially the same morphological feature. The pleurotomarian slit may vary from a shallow notch to a deep, narrow incision nearly three-quarters of the whorl circumference in depth in different genera and, perhaps, in different families. But it is morphologically, and presumably, functionally the same feature, nevertheless, and should not be symbolized by different terms that obscure the significant homology.

The growth lines in *Turbo pygmaeus* are too obscure in its usual state of preservation to show the true nature of the selenizone clearly and I am, therefore, deliberately erecting a new genus with *P. kentuckyensis* as genotype, a genus that will include *T. pygmaeus*, and that will have *Portlockia* de Koninck as a senior, but invalid, subjective synonym, rather than replacing *Portlockia*, preoccupied, by a new name. To have taken the latter course would have retained *T.*

EXPLANATION OF PLATE 79

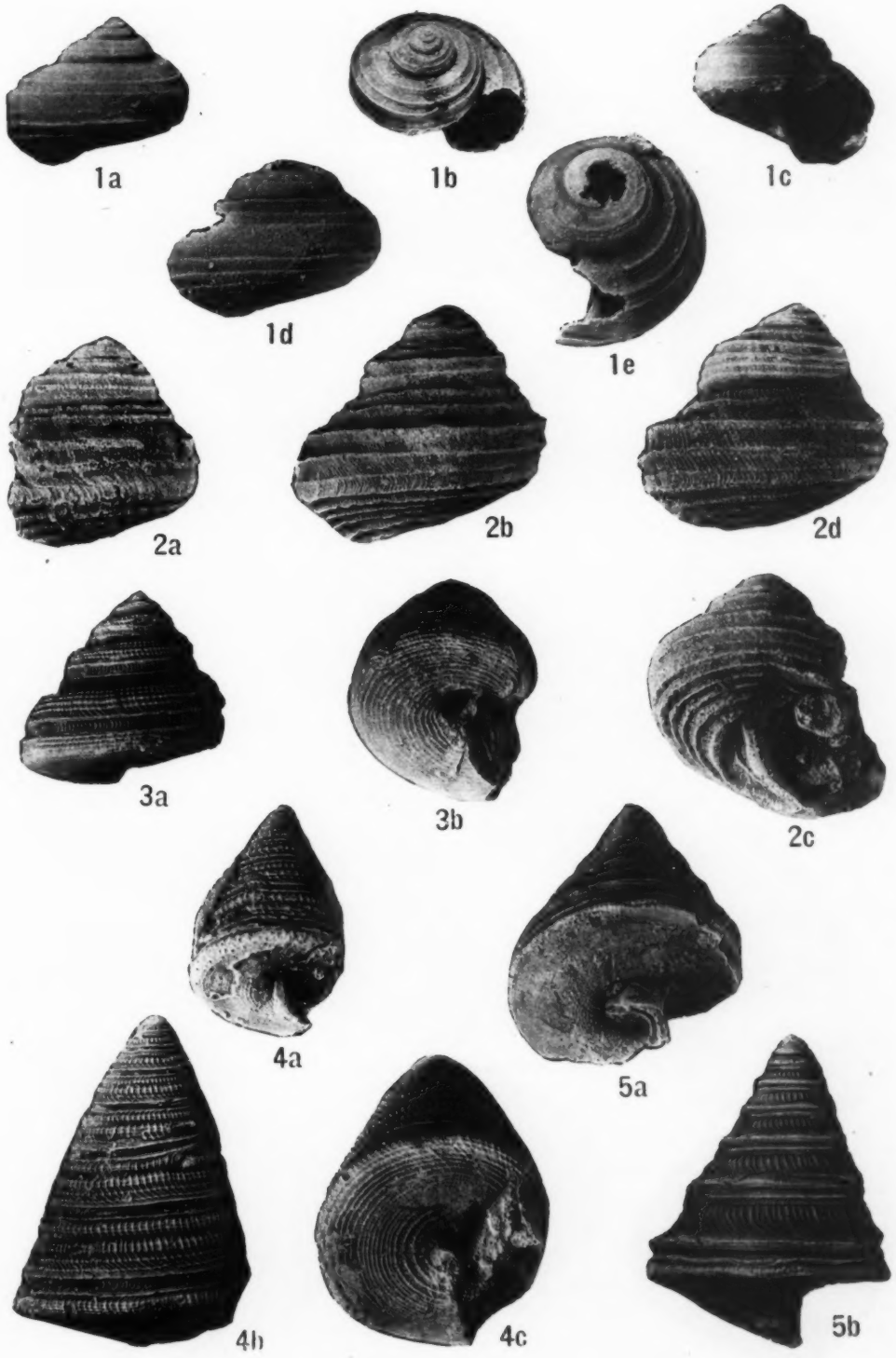
FIGS. *1a–e—Callistatia bella* Knight, n. sp. *a, b, c,* The holotype, ×2. Side, oblique apical, and apertural views respectively. The selenizone occupies the groove just above the vertical outer whorl-face. *d,* A small paratype, ×8, showing the ornamentation on the base better than the holotype. *e,* A small paratype, ×8. This specimen shows remnants of the slit although it appears much wider than it should because of the loss of the very fragile margins. Its depth before breakage appears to have been approximately as shown. (p. 578)

2a–d—Portlockiella kentuckyensis Knight, n. sp. *a,* A paratype (USNM 111768b), ×3. Close to the apertural margin of this specimen a coarse growth line, outlining the short, notch-like slit, may be seen. *b, c,* The holotype (USNM 111767), ×3, side and oblique apertural views. Note the comma-shaped lunulae of the selenizone in the lowest of the wider interspaces just above the base on figure *2b*. *d,* A paratype (USNM 111768a), ×3, side view. (p. 581)

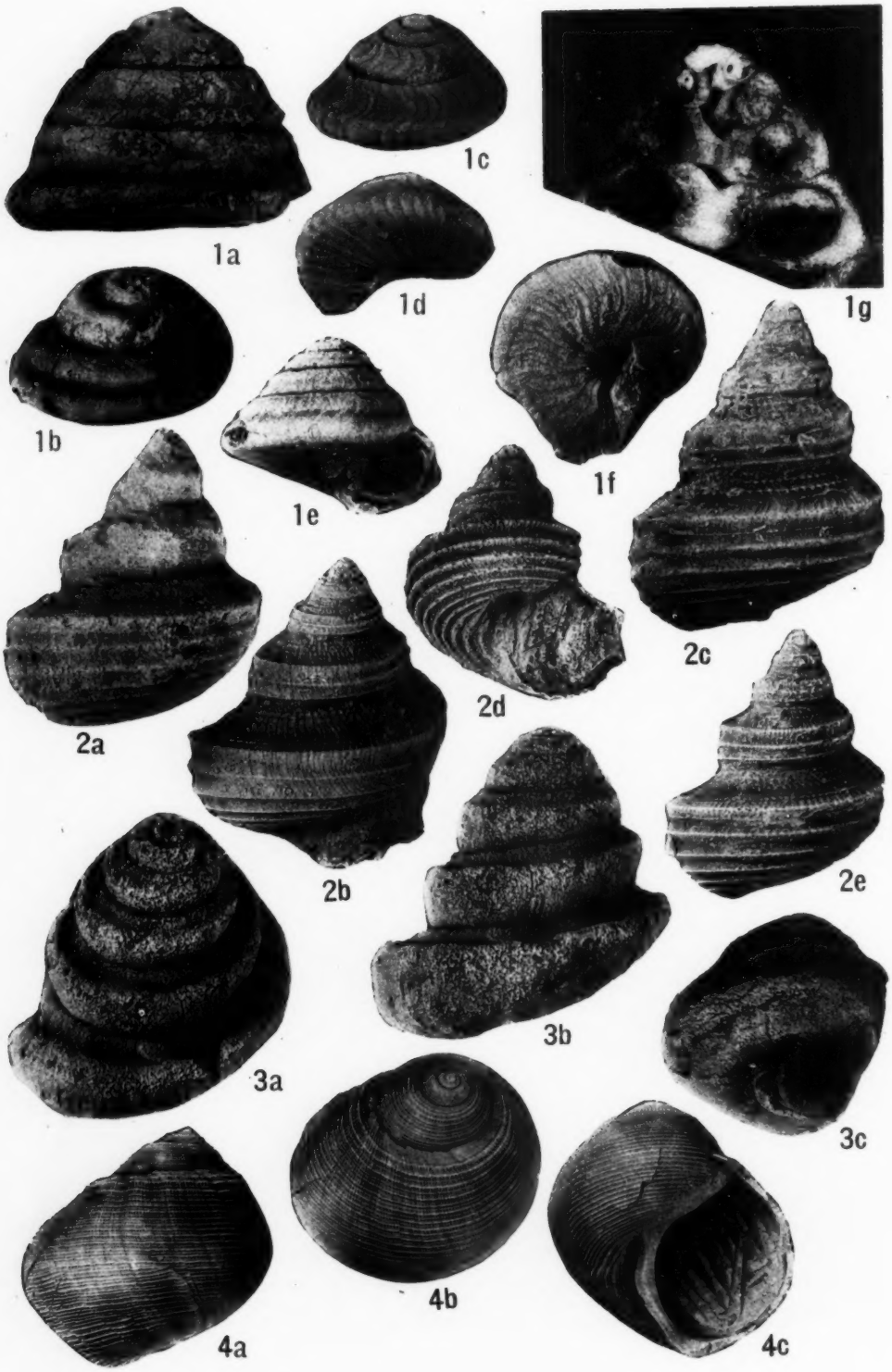
3a, b—Dictyotomaria scitula (Meek and Worthen). *a, b,* A hypotype (U.SNM 111780), ×3, side and oblique basal views respectively. (p. 576)

4a–c—Glyptotomaria apiarium Knight, n. sp. *a,* A paratype (USNM 111765), ×3, oblique basal view to show the unbroken columellar lip. *b, c,* The holotype (AMNH 26083), ×3, side and oblique basal views respectively. (p. 577)

5a, b—Spiroscala pagoda Knight, n. sp. *a, b,* The holotype (Plummer Coll. P-4341). The broken columellar lip turning about the unbilicus can be seen in *5a*. In *5b* the revolving lirae on the inner side of the costae bordering the very narrow selenizone can be seen. (p. 575)



Knight—Paleozoic Gastropods



Knight—Paleozoic Gastropods

pygmaeus as genotype by objective synonymy, with the uncertainties consequent on the difficulties of observing its characters. This is merely a nomenclatural technicality no doubt, but a technicality that is seemingly valid and will have the practical effect of eliminating uncertainties.

Previously (Knight, 1933b, p. 49) I referred *Pleurotomaria subsinuata* Meek and Worthen to *Yunnania* together with the kinds of shells I am now referring to *Portlockiella*. *P. subsinuata* is not referable to *Portlockiella* since the characters of its outer lip are not the same as those of the species now referred to the genus. *P. subsinuata* seemingly has an angular sinus of the type I erroneously attributed to *T. pygmaeus* and it is high on the margin of the lip, not low as is the notch like slit of *Portlockiella*. Although the characters of the lip of *Yunnania* are not well known there is no direct evidence that it has a sinus in any position in the outer lip. Its apertural margins, furthermore, appear to be relatively thicker than in such species as *P. subsinuata*, and I now have grave doubts as to the propriety of referring these species to it. For them I am erecting a new genus, *Amaurotoma*, described below.

In respect to ornamentation, *Yunnania termieri*, *Amaurotoma subsinuata*, and species of *Portlockiella* are very similar. *Portlockiella* differs from *Yunnania* principally in the notch-like slit that generates a selenizone low on the whorl, while in *Amaurotoma* there is a shallow angular sinus rather high on the whorl.

Range.—Mississippian. Several undescribed species of a very similar, probably related, but seemingly distinct, undescribed genus occur in the Permian rocks of Texas. I know no species of either genus in the American Pennsylvanian.

PORTLOCKIELLA KENTUCKYENSIS Knight, n. sp.
Plate 79, figures 2a–c

Description.—This species is characterized by relatively large size, coarse ornamentation, and somewhat square-faced whorls; revolving costae characteristically grouped rather than evenly distributed, a pair of costae close to the upper suture followed by a conspicuously wide, rather flat, interspace which slopes downward at an angle a little more than 50° from the vertical to a conspicuous costa that forms a shoulder separating the upper from the outer whorl face, another costa at about the middle of the other whorl face followed below by an interspace and next by the selenizone which

EXPLANATION OF PLATE 80

FIGS. *1a–g—Orecopia mccoyi* (Walcott). *a*, A large paratype (USNM 111776b), ×2, side view. This is to show the shape of mature examples. *b*, The lectotype (USNM 111755), ×2, oblique side view. This is the original of figures 1 and 1a on plate 17, of Walcott, 1884. Note the sinus high on the outer lip as shown by the growth-lines. *c*, *d*, A small, beautifully preserved paratype (USNM 111776c), ×2. Oblique side and oblique basal views. Note the sinus high on the outer lip and the tongue-like forward extension at the periphery. *e–f*, A hypotype (USNM 111777), ×2, side and basal views. Note the narrow umbilicus and the thickening surrounding it. *g*, A paratype (USNM 111776a), ×2. A columellar section of a specimen imbedded in black limestone matrix. In the last two whorls the section was ground a little beyond the narrow, tortuous umbilicus. Note the filling of all but the last two whorls. (p. 586)

2a–e—Amaurotoma humerosum (Meek and Hayden). *a*, The lectotype (USNM 1002), ×3. The original of figure 14*a*, *b*, plate 1, of Meek and Hayden, 1865. The specimen is sufficiently good to serve for recognition of the species but not adequate to illustrate its characters photographically. *b*, A hypotype from the Gonzales formation, Young County, Texas (USNM 111779), ×3, side view. Note the slight sinus shown by the growth-lines above the shoulder angulation. *c*, A hypotype from the Keechi Creek shale, northwest of Mineral Wells, Texas (Plummer Coll. P-7463), ×3, side view. Note the slight sinus shown by the growth-lines above the shoulder angulation. *d*, *e*, A hypotype from the Gonzales formation, Young County, Texas (USNM 111779), ×3, oblique apertural and side views. (p. 584)

3a–c—Micromphalus turris Knight, n. sp. *a*, *b*, The holotype (USNM 111773), ×3, oblique and side views respectively. Note the sinus in the outer lip, as shown by the growth-lines, culminating on the shoulder angle. *c*, A paratype (USNM 111774), ×3, oblique basal view to show the columellar lip and the funicular ridge. (p. 585)

4a–c—Cinclidonema texanum Knight, n. sp. The holotype (USNM 111771), ×3, side, oblique apical, and oblique apertural views respectively. Owing to the depth of the shadow, the false umbilicus shown in *4c* appears too deep. (p. 584)

is bordered above by a somewhat weak costa and below by a stronger costa that forms the angulation between the outer whorl face and the base, five or six costae on the base, evenly spaced and about equally developed except that the next to last one close to the umbilicus is a little stronger than the others and the last one, actually within the umbilical slope, is a little weaker, the revolving costae crossed by fine, sharp transverse lirae outlining the form of the outer lip; the selenizone a little narrower than the other interspaces and not so deeply concave, the lunulae somewhat asymmetrical, more comma-shaped than crescentic; the slit short, only a little more than a notch; shell moderately thick, its structure imperfectly known, but seemingly of two layers. The first 2½ whorls are smooth and deeply imbricating, the ornamentation being introduced first on the third whorl.

Dimensions.—(Estimated with allowance for breakage.)

	Number of whorls	Pleural angle	Height	Width
Holotype (USNM 11767)	5	80°	12.6 mm.	12.0 mm.
Figured paratype (USNM 47894)	6	88°	14.2 mm.	16.3 mm.
Figured paratype (USNM 111768)	5	78°	11.7 mm.	11.9 mm.

A very large poorly preserved specimen (USNM 47896) seems to have been about 20 mm. in height, but the most common dimensions are close to those of the two smaller specimens above.

Remarks.—The numerous specimens at hand are silicified and etched free by natural means. Many of then show the characters described with great clarity.

Comparisons.—*P. kentuckyensis* is a much larger and coarser shell than *P. pygmaeus* (de Koninck) and the revolving costae above the selenizone are more unevenly spaced. Another rather large, seemingly coarse, undescribed species from the "100 ft. level of the St. Louis group" at Clarksville, Tennessee, is represented by two specimens in the National Museum collections. It has fewer, evenly spaced costae and a wider pleural angle. One specimen of *P. kentuckyensis* in the National Museum recorded from the Fredonia member of the Ste. Genevieve limestone 2 miles west of Princeton, Kentucky was identified by the late Dr. E. O. Ulrich as *Ptychomphalus wortheni* Weller, 1916 (p. 253) and I suspect that the two species will ultimately prove to be the same. Yet Weller's description, which ascribes to his species a deep, rather broad slit, situated at the middle of the outer volution, prohibits the identification at least until Weller's specimens can be re-examined. His figures are unsatisfactory and one can only say from them that the two species have a superficial resemblance. The specimen shown by him as figure 31, plate 18 and questionably referred to his species is very like *P. kentuckyensis.*

Hypodigm.—Seventy two specimens as listed below.

Occurrence.—All of the specimens below are in the collections of the U. S. National Museum and the earlier collections are recorded as from beds then identified as the St. Louis Group. One later collection, mentioned above, was labeled by Dr. Ulrich as from the Fredonia member of the Ste. Genevieve limestone at Princeton, Kentucky. It is probable that all of the collections were derived from about the same beds. The collections are as follows. USNM. 111767, the holotype, USNM 111768, two figured paratypes together with 55 paratype specimens under USNM 39661 and 50575 (mixed) are from Elizabethtown, Kentucky, one figured paratype, USNM 47894 from a float boulder on hill back of Smithland, Kentucky, two paratypes, USNM 47887 from Eddyville, Kentucky, one paratype, USNM 47891 from 3 miles west of Princeton, Kentucky, 6 paratypes USNM 47899 from Clarksville, Tennessee, 2 paratypes, USNM 111769 from Elizabethtown, Kentucky, and one paratype USNM 111770, especially mentioned above, from 2 miles west of Princeton, Kentucky.

Genus CRENILUNULA Knight, n. gen.

Euomphalus (in part) of J. de C. Sowerby, 1839, (p. 616).

Pleurotomaria (in part) of Lindström, 1884 (p. 89).

Genotype, *Pleurotomaria limata* Lindström, 1884 (p. 114) equals *Euomphalus carinatus* Sowerby, 1839 (p. 616).

Diagnosis.—Turbiniform pleurotomarians with somewhat lenticular whorls, and a slit, generating a selenizone of peculiar structure, lying between a pair of thin, bordering lamellae that are greatly extended in some forms, some forms with turreted whorls and deep angular sutures and others not turreted with shallow sutures; outer lip oblique backward from the upper sutures both above and below the selenizone, with the narrow seemingly not very deep slit between its bordering lamellae at, or slightly below, the middle of the final whorl and at or above the lower suture on the upper whorls; columellar lip somewhat thickened, reflexed about the umbilicus; parietal inductura thin; base narrowly or minutely phaneromphalous; lunulae of the selenizone lamellose, with a deep notch in their anterior margins, channeled on the outward side, the lamellose lunulae often extending on their lateral margins to the full width of the lamellae bordering the selenizone; ornamentation, rather obscure revolving lirae and sharper transverse lirae or growth lamellae; shell moderately thin; seemingly of two distinct layers.

For beautifully detailed illustrations of the genotype species, and seemingly others that Lindström regarded as varieties of it, the reader is referred to Liljevall's drawings on plate 10 of Lindström, 1884.

Comparisons.—Perhaps the most obvious comparison for *Crenilunula* is with *Euomphalopterus* Roemer, 1876. *Euomphalopterus* has a wide lamellar frill somewhat as in *Crenilunula* but there is no slit nor selenizone, a channel in the anterior face of the frill taking the place of the former. Comparisons may be made also with *Tropidostropha* Longstaff, 1912. *Tropidostropha* may have, in some species, slightly extended lamellae bordering the selenizone, but this is neither certainly true nor is it a marked development if it does occur. The selenizone of *Tropidostropha* is either flat or convex and bears simple lunulae.

Range.—Silurian.

Superfamily TROCHONEMATACEA
Genus AMAURotoma Knight, n. gen.

Pleurotomaria (in part) of Hall, 1858 (p. 21); of Meek and Hayden, 1859 (p. 262); of Meek and Worthen, 1861 (p. 460).
Cyclonema (in part) of Whitfield, 1882 (p. 75).
Yunannia (in part) of Knight, 1933b (p. 49); and of Knight in Shimer and Shrock, 1944 (p. 45).

Genotype, *Pleurotomaria subsinuata* Meek and Worthen, 1861 (p. 46.).

Diagnosis.—Turbinate gastropods with rounded or shouldered whorls, revolving ornamentation, and a very slight sinus or emargination in the outer lip somewhat above the middle; whorl profile rounded in most species but strongly shouldered in some with the flat or slightly concave upper whorl surface of shouldered species sloping downward at an angle of about 50° from the vertical; outer lip gently oblique backwards from the upper suture, with the line of obliquity interrupted by a very shallow sinus situated about ¼ of the whorl-height below the upper suture on forms with rounded whorls and just above the shoulder angulation on the shouldered forms, the sinus not generating a selenizone; columellar lip thin, reflexed about the umbilicus; parietal inductura thin or wanting; base rounded, minutely phaneromphalous; ornamentation strong revolving costae with concave interspaces, a single lira frequently occupying the middle of an interspace, transverse lirae confined to the region close to the upper suture and in some species forming small nodes where they cross the two uppermost revolving lirae or costae, growth-lines commonly too fine for observation except under the most favorable conditions of preservation; shell moderately thick, clearly composed of two distinct layers, the inner probably nacreous in life.

Comparisons.—*Amaurotoma* differs from *Trochonema* Salter, 1859, and *Eunema* Salter, 1859, amongst other things, in that its revolving ornamentation is composed of more numerous elements, from *Gyronema* Ulrich in Ulrich and Scofield, 1897, in that the latter has no sinus in the outer lip. *Cyclonema* Hall, 1852, has no sinus and has a characteristically different columellar lip. *Portlockiella* (new) has a notch generating a selenizone low on the whorls. *Yunnania* Mansuy, 1912, is very similar in form and ornamentation to the species of *Amaurotoma* with rounded whorls but appears to have a thicker columellar lip and a thicker shell in general. There is no evidence that there is in *Yunnania* a sinus in the outer lip or an umbilicus.

To *Amaurotoma* I am referring *Pleuroto-*

maria leavenworthana Hall, 1858 and *P. subangulata* Hall, 1858, from the Salem limestone, Mississippian, of Indiana, although I have seen no specimens of either species with growth-lines well enough developed or preserved to indicate the course of the outer lip. From the American Pennsylvanian, I am referring to the genus, besides the genotype, an undescribed species in the National Museum Collections from the Gonzales formation, Graham group, Cisco Series, from a roadside outcrop 3.9 miles NW of Finis, Young County, Texas. All of the foregoing have rounded whorls. I am also referring to the genus *Pleurotomaria humerosa* Meek and Hayden, 1859, a shouldered species represented in the National Museum Collections not only by the two syntypes (USNM 1002) from Grasshopper Creek, Kansas, but by two specimens (USNM 111779) from the Gonzales formation at the locality in Young County, Texas, cited above and another specimen (USNM 27163) recorded simply from the Cisco Series at Graham, Texas. Another specimen of *Amaurotoma humerosum* is in the Plummer collection, P-7463 in the University of Texas, Bureau of Economic Geology, from the Keechi Creek shale, Whitt Group, Canyon Series, ¼ mile north of the Union Hill School, 6 miles north-northwest of Mineral Wells, Texas, and three specimens from the same locality in the collections of the American Museum of Natural History in New York. Since this interesting species has not been illustrated photographically heretofore I am taking advantage of this opportunity to figure it (Pl. 80, figs. 2a–e).

For a discussion and photographic illustrations of *Amaurotoma subsinuata* (Meek and Worthen) the reader is referred to Knight, 1933b (p. 49, pl. 10, figs. 2a–f; pl. 12 fig. 9).

Range.—Mississippian-Pennsylvanian.

Genus CINCLIDONEMA Knight, n. gen.

Genotype, *Cinclidonema texanum* Knight, n. sp.

Diagnosis.—Subturbinate gastropods with small spire, large body whorl and a network of fine revolving and transverse lirae; whorls rounded, somewhat more sharply rounded at the periphery than above, with a rounded shoulder a little below the upper suture; on some specimens sutures rather shallow; outer lip oblique backward from the upper suture, convex forward for the lower two-thirds and often concave forward for the upper one-third across the rounded shoulder, most strongly concave where the shoulder is most strongly developed, columellar lip slightly thickened, slightly flattened and reflexed; parietal inductura thin; base rounded, anomphalous or with a shallow pseudo-umbilicus; ornamentation numerous revolving and transverse lirae, increasing in number by intercalation and commonly, therefore, of two orders; shell moderately thin, of two distinct layers, the outer layer very thin.

Comparisons.—*Cinclidonema* resembles *Littorinides* Knight, 1937, (equals *Rhabdopleura* de Koninck, 1881, preoccupied) in respect to its shape and ornamentation but lacks the plate-like tooth on the columellar lip developed in that genus. One may compare it also to *Omphalonema* Grabau, 1936, to which it also bears some resemblance. Owing to an inadequate original description and unilluminating illustrations of the genotype of *Omphalonema*, there are some uncertainties as to its characters, but it seems to have a somewhat differently shaped spire and a narrowly phaneromphalous base. It is possible that *Cinclidonema* may find a place in the synonymy of *Omphalonema* when the characters of the genus bearing that name become better known.

Range.—Pennsylvanian.

CINCLIDONEMA TEXANUM Knight, n. sp.
Plate 80, figures 4a–c

Description.—With the characters of the genus; within the genus seemingly characterized by moderately shouldered whorls, a rather narrow, reflexed columellar lip, a minute false umbilicus, and numerous closely spaced fine revolving and transverse lirae, the revolving lirae on the two specimens at hand numbering over fifty, including intercalated lirae. It is probable that a larger suite of specimens would show considerable variation in respect to the features noted.

Dimensions.—(Estimated with allowance for breakage.)

	Number of whorls	Pleural angle	Height	Width
Holotype, USNM 111771	5½	101°	19.5 mm.	18.5 mm.
Paratype, USNM 111772	6	94°	26.8 mm.	24.0 mm.

Remarks.—Both specimens are unusually well preserved from a clay matrix. The holotype is an almost perfect specimen, lacking only a little of the margin of the outer lip.

Comparisons.—An undescribed species of the genus is fairly abundant in the upper Marble Falls limestone and the Smithwick shale of the Bend group, Pennsylvanian in Texas. It is possible that this is the same as *C. texanum* but a decision on this point and comparisons had best await the description of the Bendian form, which is in progress. I am unacquainted with any other species.

Hypodigm.—The two specimens in the National Museum collection listed below.

Occurrence.—The holotype, USNM 111771, and the paratype, USNM 111772, were both derived from the Bridgeport clay of the Graford group, Canyon series, Pennsylvanian, at the clay pit on the north edge of Bridgeport, Wise County, Texas. I have also noted two specimens in the Plummer collection, P-3071 and P-4755, in the Bureau of Economic Geology, University of Texas, both from the same beds at the same locality. If the species mentioned above as being abundant in the upper part of the Bend group of Texas proves to be the same as *C. texanum* its range is extended downward in the section at least that far.

	Number of whorls	Pleural angle	Height	Width
Holotype (USNM 111773)	7	45°	15.8mm.	13.2 mm.
Figured paratype (USNM 111774)	6	51°	11.5 mm.	10.5 mm.

Genus MICROMPHALUS Knight, n. gen.

Genotype, *Micromphalus turris* Knight, n. sp.

Diagnosis.—Somewhat bee hive-shaped, trochiform gastropods with wide, low, shouldered whorls, and a shallow sinus in the outer lip over the whorl shoulder; whorl-profile concave on the shoulder within the rounded bordering, somewhat upraised angulation, rounded on the narrow outer whorl-face, rather flatly rounded on the base; margin of the outer lip somewhat convex forward close to the upper suture, sweeping backward across the concave band on the shoulder and turning downward and slightly oblique forward on the outer whorl-face; parietal inductura thin; columellar lip joining the lower lip sub-angularly, somewhat thickened at the juncture, the thickening generating a funicle, thin above and reflexed about the umbilicus, base flatly rounded, minutely phaneromphalous; ornamentation, other than growth lines, wanting; shell moderately thick, its structure unknown.

Comparisons.—*Micromphalous* suggests a high-spired *Euomphalus* or shouldered *Straparolus* but unlike those genera it does not have a widely open umbilicus. In some respects it resembles *Orecopia* (new) but the outer lip does not project strongly forward below the sinus, and the angle between the outer whorl-face and the base is not thickened.

Range.—Mississippian.

MICROMPHALOUS TURRIS Knight, n. sp.
Plate 80, figures 3a–c

Description.—Since only a single species of the genus is known at present the above generic diagnosis will serve as the description.

Dimensions.—(Estimated with allowance for breakage.)

Remarks.—All of the specimens are silicifications etched free by natural processes. Most of them are rather imperfect and some are distorted, but from them one can learn the characters of the species readily and with considerable assurance.

Hypodigm.—Fifteen specimens, all in the same collection from the same beds at the same locality.

Occurrence.—From the same beds and at the same locality as the holotype of *Portlockiella kentuckyensis* (new) at Elizabethtown, Kentucky, believed to be the Ste. Genevieve limestone. All the specimens are

in the collections of the U. S. National Museum, the holotype under number USNM 111773, the figured paratype under USNM 111774, and the thirteen unfigured paratypes under USNM 50576.

Superfamily OMPHALOTROCHACEA, n. fam.
Genus ORECOPIA Knight, n. gen.
Platyschisma (in part) of Walcott, 1884, p. 188).

Genotype, *Platyschisma? mccoyi* Walcott, 1884 (p. 188).

Diagnosis.—Rotelliform to bee-hive-shaped, trochiform gastropods with a deep U-shaped sinus high on the outer lip and the peripheral section of the same lip extending forward in a broad, tongue-like projection, and a minutely phaneromphalous base; whorl-profile gently arched above the periphery, the arch being broken in some species by a groove just above the periphery, the periphery itself developing into a rounded flange at mature stages in some species, sharply rounded over the periphery, and flat or flatly rounded on the base; the margin of the outer lip with a rather deep U-shaped sinus, the margin sweeping strongly backward soon after leaving the upper suture, then, turning roundly in the sinus and sweeping strongly forward for a space, turning roundly on the periphery to a moderate backward obliquity on the base, thus leaving a short, rounded forward projection of the lip at the periphery; columellar lip somewhat thick, subangular and thickened where it joins the lower lip; parietal inductura thin at the aperture; base narrowly to minutely phanerompahlous; ornamentation, other than gross sculpture and growth lines almost absent although a few specimens of the genotype species show regular transverse undulations forming broad crenulations where they cross the periphery; shell very much thickened by secondary deposits within the whorls, the earlier whorls completely filled, only the last two or three remaining open, seemingly not of markedly different layers.

Comparisons.—The genus to which *Orecopia* shows the greatest resemblance is *Omphalotrochus* Meek, 1864. The most obvious difference is that the umbilicus in *Omphalotrochus* is wide, while that of *Orecopia* is very narrow and bordered by a thickened angulation. In the latter respect *Orecopia* resembles *Micromphalus* (new) but differs from that genus in the tongue-like forward extension of the outer lip at the periphery, a feature shared with *Omphalotrochus*. *Platyschisma* McCoy, 1844 is a genus of thin-shelled species with rounded whorls, with a U-shaped sinus but without the forward extension of the lip. *Pycnomphalus* Lindström, 1884, resembles *Orecopia* in some respects but has no sinus in the outer lip.

Besides *O. mccoyi*, the genotype, I refer to *Orecopia*, a number of undescribed species in the Devonian of the western United States, and Canada. Certainly if the specimens in the National Museum labeled *Platyschisma kircholmensis* Keyserling (USNM 60922) and *P. uchtensis* Keyserling (USNM 60907) from Devonian beds at Kircholm, Livonia and on the river Uchta, Timan, are correctly identified those species, too, are referable to *Orecopia*.

ORECOPIA MCCOYI (Wolcott), 1884
Plate 80, figures 1a–g

Platyschisma? McCoyi Wolcott, 1884 (p. 188, pl. 17, figs. 1, 1a–c).

I shall not redescribe this species here but since it has not been illustrated photographically heretofore I shall take this opportunity to publish photographs of some specimens. These include the lectotype (USNM 111775), three paratypes not hitherto figured (USNM 111776a, 111776b, and 111776c), and a hypotype (USNM 111777) collected from the Valentine member of the Sultan limestone, in the center of the NW ¼, sec. 20, T. 25 S., R. 58 E., Goodsprings district, Nevada.

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A CORRECTION

In my recent paper on *Some new genera of the Belleraphontacea* I gave an erroneous description of University of Texas, Bureau of Economic Geology locality 205-T-13 (JOUR. PALEONT., vol. 19, p. 339). This description should read as follows: "San Saba Co., Texas; 1.25 miles southwest of Bend in gullies on the east side of the Bend—Chappel road." I am indebted to Mrs. Helen Jeanne Plummer for calling this error to my attention.

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RECTUVIGERINA, A NEW GENUS OF FORAMINIFERA FROM A RESTUDY OF SIPHOGENERINA

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ABSTRACT—A restudy of the genus *Siphogenerina* is based upon the original figure and description of the genotype, *S. costata* Schlumberger, and upon specimens of *S. raphanus* (Parker and Jones)—possibly synonymous with *S. costata*. Forms having a triserial neanic stage, indicating derivation from *Uvigerina*, are separated from those like the genotype which have a biserial or bolivine neanic stage. The triserial group is placed in a new geuus, *Rectuvigerina*, which is divided into two subgenera: *Rectuvigerina, s. s.*, having straight sutures, and *Transversigerina*, having arched sutures. *R. multicostata* (Cushman and Jarvis) is selected for the genotype of *Rectuvigerina* and *R. transversa* for the subgenotype of *Transversigerina*. An illustrated key is given to the two subgenera and thirty-five species of *Rectuvigerina*. Four similar genera, *Sagrina*, *Uvigerina*, *Uvigerinella*, and *Siphogenerinoides*, are discussed and means of separating them from *Rectuvigerina* listed. The three centers of geographic distribution of *Rectuvigerina*, California, Caribbean Sea, and New Zealand, are shown on a world map, and a geologic chart is presented illustrating the range—Eocene to Recent—of the genus, which has its greatest number of species in upper Oligocene and lower Miocene strata.

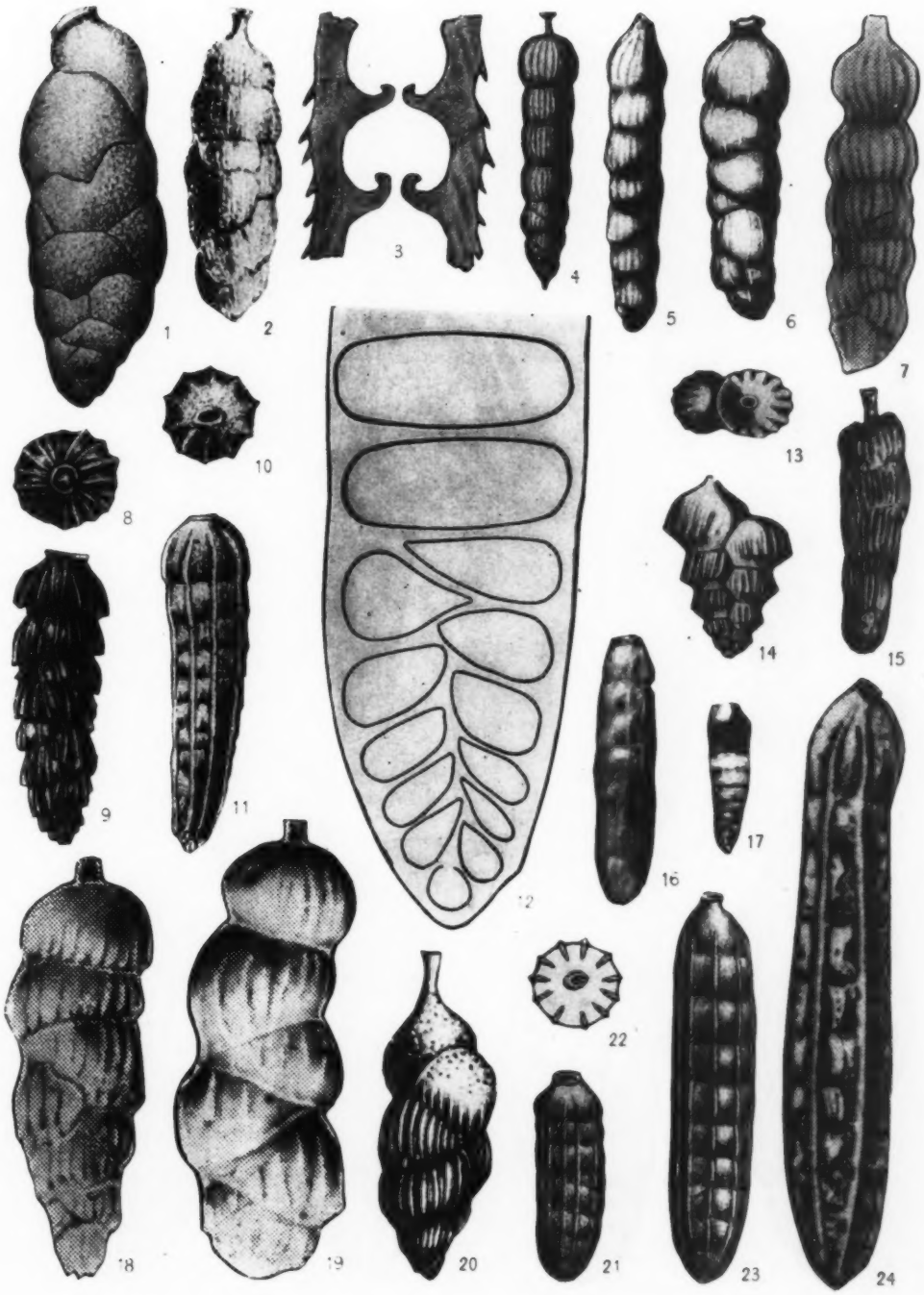
INTRODUCTION

THE GENUS *Siphogenerina* was proposed by Schlumberger in 1883 to include nodosarian forms which had an internal tube connecting the chambers. Since then, more than fifty species have been assigned to the genus, apparently entirely on the basis of having nodosarian chambers and a siphon. However, a survey of the comparative ontogeny of specimens shows that *Siphogenerina* may be divided into two distinct groups. One group has a triserial neanic stage and shows a close relationship to *Uvigerina*. The other group, including the genotype, has a

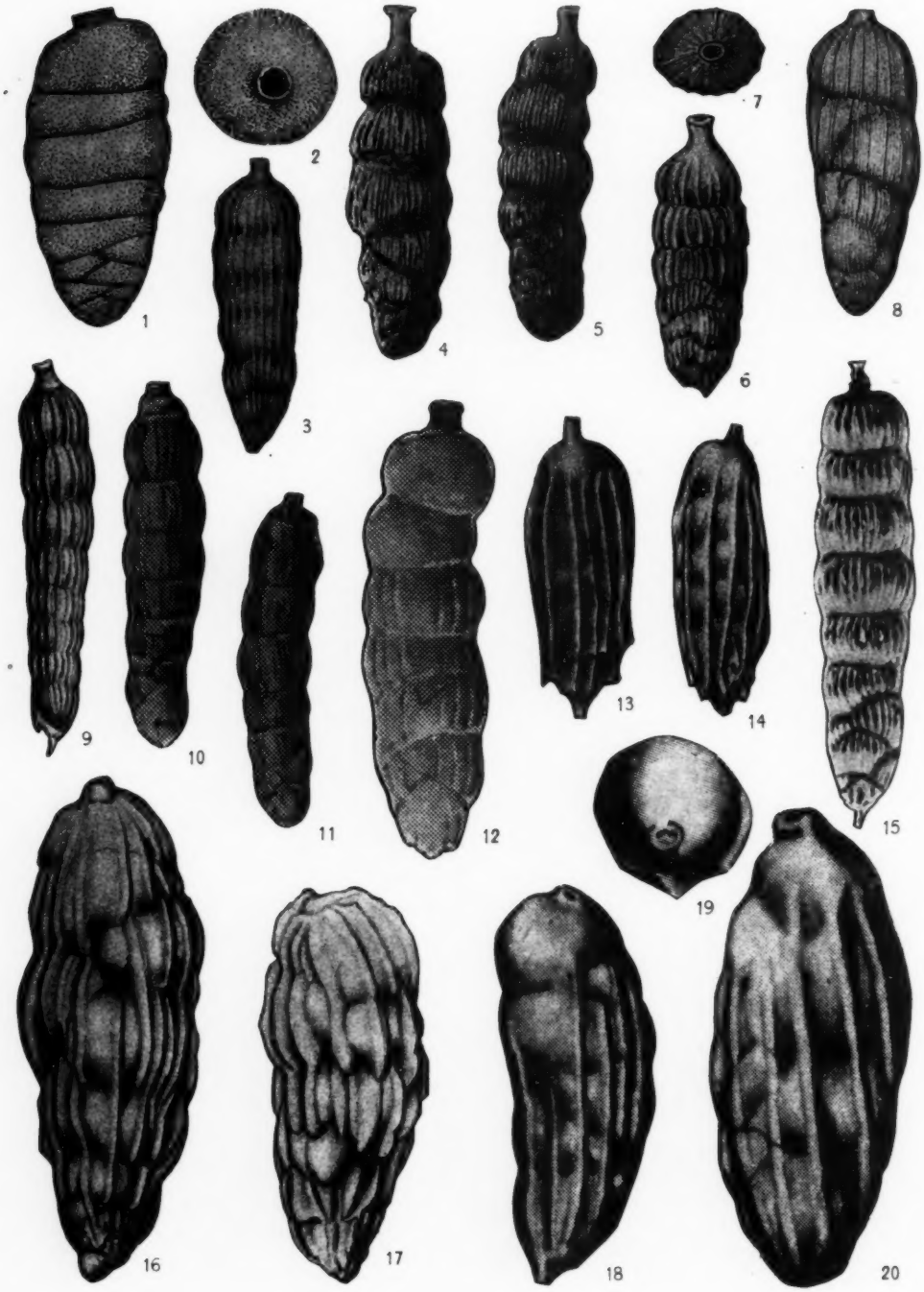
EXPLANATION TO PLATE 81

All figures after the original unless otherwise specified.

FIGS. *1*—*Uvigerinella californica* Cushman. Holotype, ×75. (p. 603)
2—*Rectuvigerina nicoli* Mathews, n. sp. New name for *Uvigerina* (*Sagrina*) *nodosa* d'Orbigny of Parker and Jones; see discussion, p. 000. Holotype (Parker and Jones original figure), ×60. Repository unknown. (p. 593)
3, 4—*Rectuvigerina striata* (Schwager). Original figures; *4*, side view, approx. ×42; *3*, section, ×200. (p. 597)
5—*Rectuvigerina panggoeensis* (Le Roy). Holotype, ×60. (p. 595)
6—*Rectuvigerina fredsmithi* (Garrett). Holotype, ×67. (pl 592)
7—*Rectuvigerina vesca* (Finlay). Holotype, ×60. (p. 598)
8, 9—*Rectuvigerina mayi* (Cushman and Parker). Holotype, apertural and side views, ×50. (p. 593)
10, 11—*Siphogenerinoides plummeri* (Cushman). Holotype, aperutal and side views, ×65. (p. 603)
12, 16, 17, 21–23—*Siphogenerina raphanus* (Parker and Jones). *12*, hypotype, section after Cushman, 1913, ×200; *16*, hypotype, megalospheric specimen from Fiji Islands, ×25; *17*, hypotype, microspheric juvenile specimen from Fiji Islands, ×25; *21*, original figure, ×30; *22–23*, original figures, apertural and side views, ×30. (p. 589)
13, 14—*Sagrina pulchella* d'Orbigny. Original figure, after Ellis and Messina, ×50. (p. 601)
15—*Rectuvigerina irregularis* (Bagg). Original figure, magnification not given. (p. 592)
18—*Rectuvigerina ongleyi* (Finlay). Holotype, ×60. (p. 594)
19—*Rectuvigerina prisca* (Finlay). Holotype, ×90. (p. 595)
20—*Uvigerina pigmea* d'Orbigny. Original figure, magnification not given. (p. 601)
24—*Siphogenerina costata* Schlumberger. Original figure, ×56. (p. 589)



Mathews—Genus Rectuvigerina



Mathews—Genus Rectuvigerina

compressed biserial stage and shows a closer affinity to *Bolivina* or *Rectobolivina* than to *Uvigerina*. This conclusion was reached from a study of many thin-sections of specimens belonging to various species of *Siphogenerina*. The resulting division leaves the triserial group with thirty-five species and the biserial group with about fifteen species, the exact number dependent upon what forms are to be included in *Rectobolivina* Cushman.

The triserial species of *Siphogenerina* are becoming increasingly important in Tertiary stratigraphy. This is particularly true in New Zealand, California, the Caribbean region, and in states bordering the Gulf of Mexico. Some species of the group, such as "*Siphogenerina*" *transversa*, have short stratigraphic ranges and are geographically widespread. These characteristics make them good index fossils and permit age correlation between such widely separated areas as California and the island of Trinidad, British West Indies.

REVISION OF SIPHOGENERINA BASED ON GENOTYPE

The genotype of *Siphogenerina* is *S. costata* Schlumberger, 1883, by subsequent designation, Cushman, 1927 (p. 190). A free translation of Schlumberger's original description is as follows:

> Shell elongated, fusiform, composed of numerous chambers whose sutures are almost on a level with the test. The two or three last chambers are marked by a constriction. Test smooth and brilliant, ornamented with 5 to 6 longitudinal, continuous and prominent ribs. Aperture round, surrounded by a lip; length: 1.47 mm.

S. costata (plate 81, fig. 24) is probably distinct from *S. raphanus* (Parker and Jones, 1865) (plate 81, fig. 23). These closely related and often synonymized species (Galloway, 1933, p. 374) are dissimilar in three ways: (1) *S. costata* has 5 to 6 costae; *S. raphanus* usually has 10 to 12. (2) The test of *S. costata* is constricted near the final chamber; the test of *S. raphanus* is not. (3) The aperture of *S. costata* is small; the aperture of *S. raphanus* is large (see type figures). Localities given by Schlumberger for *S. costata* are Tahiti and New Caledonia. Foraminiferal material was examined from this region (Society Islands), and specimens of *S. raphanus* were found. One specimen has as few as 7 costae; another has a slight constriction near the final chamber, but none correspond in all criteria with Schlumberger's figure and description of *S. costata*.

The following generic revision is based on the type figure and description of *S. costata* and specimens of *S. raphanus*. Observations on the latter show the microspheric form to have a biserial neanic stage (plate 81, figs. 12, 17). This character was considered by Parker and Jones (1865, p. 364) to be a form of acceleration in which the triserial mode of growth was obsolete. Exception to this view is taken here. The biserial mode of growth exhibited by *S. raphanus* should be considered distinct from that found in specimens where a few biserial chambers are present between triserial and uniserial stages. The latter has resulted from a tightening and lengthening of the coil in high-spiral forms so that a complete revolution is made

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EXPLANATION TO PLATE 82

All figures after the original unless otherwise specified.

FIGS. *1, 2—Rectuvigerina hughesi* (Cushman). Holotype, side and apertural views, ×35. (p. 592)
3—Rectuvigerina hubbardi (Galloway and Heminway). Holotype, ×40. (p. 592)
4, 5—Rectuvigerina optima (Cushman). *4*, Holotype; *5* paratype, ×50. (p. 594)
6—Rectuvigerina multicostata (Cushman and Jarvis). Holotype, ×55 (p. 593)
7, 8—Rectuvigerina costostriata (Galloway and Heminway). Holotype, apertural and side views, ×54. (p. 591)
9—Rectuvigerina striatissima (Stache). Original figure, var. *alpha*, ×50. (p. 597)
10, 11—Rectuvigerina pohana (Finlay). *10*, Holotype; *11*, paratype, ×60. (p. 595)
12—Rectuvigerina postprandia (Finlay). Holotype, ×60. (p. 595)
13, 14—Rectuvigerina basispinata (Cushman and Jarvis). Original figures, ×55. (p. 590)
15—Rectuvigerina rerensis (Finlay). Holotype, ×60. (p. 596)
16, 17—Rectuvigerina smithi (Kleinpell). *16*, Holotype; *17*, paratype, ×65. (p. 596)
18, 19—Rectuvigerina pseudococoaensis (Cushman and Kleinpell). Holotype, side and apertural views, ×50. (p. 595)
20—Rectuvigerina nodifera (Cushman and Kleinpell). Holotype, ×50. (p. 594)

by 2 instead of 3 chambers. This may be seen in "*S.*" *costostriata* Galloway and Heminway, 1941 (plate 82, fig. 8). Note the angle of sutures and overlapping chambers, which indicate a continuation of the spiral form. Boliviniform biserial arrangement, illustrated by *S. raphanus*, in which chambers are compressed and side by side, develops directly from the proloculus or from planospiral coiling. This is different and has no close phylogenetic relationship to the transitional biserial mode of growth, as shown by "*S.*" *costostriata*.

Siphogenerina, as conceived here, includes only those species with a biserial beginning. The genus should be removed from the Uvigerinidae and placed in the Heterohelicidae, as used by Galloway (1933), where it shows a close relationship to *Rectobolivina* Cushman, 1927, and *Bifarina* Parker and Jones, 1872.

The group of species with a triserial neanic stage developing from *Uvigerina* and formerly placed in "*Siphogenerina*" is now anonymous. For this group a new genus is erected.

SYSTEMATIC DESCRIPTIONS

Family UVIGERINIDAE Galloway and Wissler, 1927

Subfamily UVIGERININAE Cushman, 1913

Genus RECTUVIGERINA Mathews, new genus

Genotype, *Siphogenerina multicostata* Cushman and Jarvis, 1929.

Description of genus.—Test free, elongate, round in cross section; initial chambers triserial, later uniserial with or without intermediate biserial stage; longitudinal costae either continuous or interrupted by sutures; wall calcareous, perforate; internal tube connecting later chambers, terminating in round aperture with phialine lip.

Remarks.—This genus was apparently derived from *Uvigerina* by the addition of one or more uniserial chambers and the development of an internal tube. Phylogeny of individual species indicates a multiple origin through various species of *Uvigerina*.

The following is a list of species allocated to *Rectuvigerina* and accompanied by original descriptions, quoted in full. Varietal names are raised to specific rank where differences are considered distinct.

RECTUVIGERINA BASISPINATA (Cushman and Jarvis)

Plate 82, figures 13, 14

Siphogenerina basispinata[1] Cushman and Jarvis, 1929, Cushman Lab. Foram. Research Contr., vol. 5, pt. 1, no. 72, p. 13, pl. 3, figs. 4, 5.

Type locality.—"Sagrina beds" Trinidad point, Oropouche Lagoon, Trinidad, B.W.I.

Type specimen.—Cushman no. 10054.

Original description.—

Test elongate, about 3 times as long as broad, early portion triserial and tapering, later portion uniserial, sides nearly parallel; chambers comparatively few, fairly distinct, not depressed; wall ornamented in the later portion by a series of distinct, plate like longitudinal costae, somewhat unevenly placed, continuous over the chambers, but over the early portion projected into spine-like processes; aperture circular, with a smooth cylindrical neck and phialine lip. Length 0.85 mm.; breadth 0.30 mm.

RECTUVIGERINA BRANNERI (Bagg)

Plate 83, figures 17–19

Sagrina branneri Bagg, 1905, U. S. Geol. Survey Bull. 268, p. 40, pl. 7, fig. 4.

Sagrina californiensis Bagg, idem, p. 41, pl. 7, fig. 5.

Sagrina elongata Bagg, idem, p. 41, pl. 7, fig. 6.

Siphogenerina branneri (Bagg) Cushman, 1926, U. S. Nat. Museum Proc., vol. 67, art. 25, p. 7, pl. 1, figs. 7–9.

Type locality.—Rancho de Encinal, San Luis Obispo County, Calif.

Type specimen.—Repository of holotype not given. Hypotypes, Stanford Univ. Micropaleo. Type Coll. no. 5917 and 884, L.S.J.U. locality 691, Reliz Canyon, Calif.

Original description.—

In the material from California occur a large number of nodosarian types with expanded elongated apertures of the *Sagrina* type. The surface is decorated with a large number of longitudinal costae, as many as twenty occurring on some specimens. There are three distinct types of these, possibly more. These types are closely allied with the forms described and figured by Professor Brady in the Challenger Report under the name *Sagrina raphanus* Parker and Jones. They all differ from these figured types in the larger number of striations, and in the method of septal formation. In the California specimen the septa are arched between chambers and the arches extend from one surface costal ridge to another, and furthermore the striations are continuous, not broken, and extend to the very aperture though

[1] Synonymies partial, including only generic changes and important homonyms, synonyms, and misidentifications.

the last chamber has them as fine lines running to the phialine aperture. The form selected to represent the species *Sagrina branneri* is acuminate and has about ten successive chambers closely set and with the surface marked by about sixteen longitudinal striations. Aperture raised, tubular with flaring opening. Shell walls white, perforate. The form is large, nearly one-sixteenth inch in length.

Remarks.—With the above species, which was first named *Sagrina branneri* (pl. 83, fig. 17), Bagg (1905, p. 41) described two other forms which he named *Sagrina californiensis* (plate 83, fig. 18) and *Sagrina elongata* (pl. 83, fig. 19). Kleinpell writes (1938, p. 300),

. . . the original sample . . . contains abundant specimens which fit Bagg's original description and figures of *S. branneri*, "*S. californiensis*," and "*S. elongata*" very well. Subsequently Cushman has grouped Bagg's three forms under one species; and although the slightly stronger costae of "*S. elongata*" might possibly be considered a basis for a varietal distinction, Cushman's usage is followed here.

When Cushman (1926a, p. 7) synonymized these forms he figured in addition to Bagg's figures a specimen of his own. Kleinpell states (1938, p. 300),

Cushman's figure, however, appears to represent a very different form with fewer heavier costae, possibly *S. nuciformis*.

RECTUVIGERINA COLLOMI (Cushman)
Plate 83, figure 1

Siphogenerina collomi Cushman, 1925, Cushman Lab. Foram. Research Contr., vol. 1, pt. 1, p. 2, pl. 4, fig. 3.

Type locality.—Sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, Calif.

Type specimen.—Cushman Lab. Foram. Res., Coll. no. 4325.

Original description.—

Test large for the genus, fusiform, greatest width above the middle; early chambers irregularly spiral, later ones uniserial, distinct; sutures depressed, strongly curved, extending back on the costae to a considerable distance; test ornamented with very high, plate-like costae, usually ten in number, last-formed chamber smooth; aperture with a very short cylindrical neck and phialine lip. Length up to 1.60 mm.; breadth 0.65 mm.

RECTUVIGERINA COSTOSTRIATA (Galloway and Heminway)
Plate 82, figures 7, 8

Siphogenerina costostriata Galloway and Heminway, 1941, Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 432, pl. 34, fig. 5.

Type locality.—P. 254, Ponce formation, Porto Rico.

Type specimen.—Indiana University, no. 4147.

Original description.—

Test of medium size, slender, the early part conical, the later part somewhat compressed; the early part sharply rounded, gradually expanding to the broadly rounded apertural end; chambers triserial and closely appressed in the first third of the test, becoming biserial in the middle third and uniserial in the final third, progressively more inflated from the middle to the oral end; surface ornamented with fine striae in the first one-third of the test, about 20 in a width of 0.2 millimeter; the later two-thirds with thin, low costae, 5 to 6 in a width of 0.2 millimeter, between each pair of which there are 2 or 3 much smaller, raised striae; neither the costae nor striae cross the sutures; aperture oval, without phialine lip, at the end of a short neck, which is not set in a depression. Length, 0.78 millimeter; width, 0.26 millimeter; thickness, 0.21 millimeter.

RECTUVIGERINA CUBENSIS (Cushman and Bermudez)
Plate 83, figures 10, 11

Siphogenerina transversa var. *cubensis* Cushman and Bermudez, 1937, Cushman Lab. Foram. Research Contr., vol. 13, pt. 1, p. 16, pl. 2, figs. 8, 9.

Type locality.—Bermudez Sta. 31, Havana Province, Cuba.

Type specimen.—Cushman no. 23411.

Original description.—

Variety differing from the typical [*S. transversa* Cushman, 1918] in the higher costae and more fusiform shape. Length 1.00–1.40 mm.; diameter 0.55–0.68 mm.

RECTUVIGERINA CUMINGSI (Galloway and Heminway)
Plate 83, figures 2, 3

Siphogenerina cumingsi Galloway and Heminway, 1941, Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 433, pl. 34, fig. 6.

Type locality.—Holotype, P. 3; paratype P. 2, Ponce formation, Cuba.

Type specimen.—Indiana University, holotype, no. 3983; paratype, no. 3984.

Original description.—

Test elongate, subcylindrical; apical end pointed in the more elongate, microspheric form, bluntly rounded in the stouter megaspheric form; triserial stage very short, uniserial stage with about 7 chambers which are about ¾ as long as wide; sutures flush with the surface, curved adorally between the costae; wall ornamented by 7 to 8 longitudinal costae, each continuous the length

of the test except for the last chamber; apical end spinose; triserial portion of megaspheric test with short costae intercalated between the primary costae; apertural end rounded with a short neck; aperture terminal, round, with slight phialine lip. Dimensions of average megaspheric form: length, 0.94 millimeter; diameter, 0.26 millimeter. Dimensions of figured microspheric form: length, 0.86 millimeter; diameter, 0.26 millimeter. Maximum size of microspheric form: length, 1.26 millimeters; diameter, 0.30 millimeter.

RECTUVIGERINA FREDSMITHI (Garrett)
Plate 81, figure 6

Siphogenerina fredsmithi Garrett, 1939, Jour. Paleontology, vol. 13, no. 6, p. 577, pl. 66, fig. 1.

Type locality.—Core depth 5,711–5,714 feet, Stanolind Oil and Gas Co., no. B-2 Pipkin, Big Hill Prospect, Jefferson County, Texas.

Type specimen.—Stanolind Oil and Gas Co., Houston, Texas, no. 1952.

Original description.—

Test small, elongate, slender, tapering in the early portion, uniform in diameter in the later portion, chambers in early portion irregularly triserial, later becoming uniserial, inflated, distinct; sutures distinct, deeply depressed, surface ornamented by fine, low costae, which are broken by the sutures, aperture small, circular, terminal, with a short neck and phialine lip.

Dimensions of holotype no. 1952 from core at 5,711–5,714 feet: length, 0.63 mm.; width, 0.18 mm.

RECTUVIGERINA HUBBARDI
(Galloway and Heminway)
Plate 82, figure 3

Siphogenerina hubbardi Galloway and Heminway, 1941, Sci. Survey Puerto Rico and Virgin Islands, vol. 3, pt. 4, p. 434, pl. 34, fig. 2.

Type locality.—P. 2, Ponce formation, Cuba.

Type specimen.—Indiana University, no. 3985.

Original description.—

Test elongate, cylindrical, nearly circular in cross section; triserial portion about $\frac{1}{3}$ the length of the test, 4 chambers in uniserial part of the test; apical end either blunt in what is evidently the megaspheric form, or pointed in the microspheric form; most specimens with small spinosities near the apical ends of the costae; chambers slightly inflated; uniserial chambers broader than long; sutures depressed in early part of the test, only slightly depressed in later part; wall ornamented by about 20 longitudinal costae most of which are continuous from chamber to chamber; aperture terminal, circular with rounded lip at the end of a definite neck. Total length, 1.00 millimeter; diameter, 0.30 millimeter; length of neck, 0.06 millimeter.

RECTUVIGERINA HUGHESI (Cushman)
Plate 82, figures 1, 2

Siphogenerina hughesi Cushman, 1925, Cushman Lab. Foram. Research Contr., vol. 1, pt. 2, p. 36, pl. 7, fig. 4.

Type locality.—Near Chimney Rock, San Luis Obispo County, Calif.

Type specimen.—Cushman no. 4364.

Original description.—

Test elongate, fairly thick, two or three times as long as broad, circular in transverse section; chambers short and broad, the early chambers irregularly spiral, later ones uniserial; sutures distinct and depressed; wall thick, the exterior smooth throughout; aperture terminal, rounded, with a short neck and slight lip.

Length, 1 mm. or slightly more; breadth 0.50 mm.

RECTUVIGERINA IRREGULARIS (Bagg)
Plate 81, figure 15

Sagraina irregularis Bagg, 1908, U. S. Nat. Museum Proc., vol. 34, no. 1603, p. 152, pl. 5, figs. 8–10.

Siphogenerina irregularis (Bagg). Cushman, 1913, U. S. Nat. Museum Bull. 71, pt. 3, p. 109, pl. 47, figs. 6, 7.

Type locality.—Albatross Sta. D. 4025, at 275–368 fathoms, near Hawaiian Islands.

Type specimen.—U. S. Nat. Mus. no. 8200.

Original description.—

Test elongate with irregularly set stout segments separated by septa which are but little depressed, giving a nodosarian aspect to the shell. The distal end is narrowly rounded without being acuminate the anterior abruptly truncated with an invaginated siphonal tube at the end of which is the circular flaring aperture. This peculiar inset effect of the apertural tube, together with the irregularly set chambers, affords a ready means of separation of the form from *Sagraina striata* Schwager, which the species somewhat resembles. The striations of the surface are sinuous, delicate and fairly persistent, but they branch in some places. The texture of the shell is fine semitranslucent hyaline calcareous matter and the tests are rather large and well built for the genus.

RECTUVIGERINA KLEINPELLI (Cushman)
Plate 83, figure 15

Siphogenerina kleinpelli Cushman, 1925, Cushman Lab. Foram. Research Contr., vol. 1, pt. 1, p. 3, pl. 4, fig. 5.

Type locality.—Sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, Calif.

Type specimen.—Cushman no. 4327.

Original description.—

Test about twice as long as broad, greatest

breadth at the apertural end, thence irregularly tapering to the initial end; chambers distinct; sutures depressed, very slightly if at all curved; wall ornamented with about fifteen very low costae, not at all lamellate, not continuing onto the last-formed chamber; aperture with a very short cylindrical neck and slight phialine lip. Length up to 1 mm.; breadth 0.50 mm. This species may be distinguished from *S. reedi* by the much lower and less prominent costae, and the lack of curvature in the sutures.

RECTUVIGERINA KUGLERI
(Cushman and Renz)
Plate 83, figures 20, 21

Siphogenerina kugleri Cushman and Renz, 1941, Cushman Lab. Foram. Research Contr., vol. 17, pt. 1, p. 22, pl. 3, fig. 23.

Type locality.—Pozon, District Acosta, State Falcon, Venezuela.

Type specimen.—Cushman Lab. Foram. Res., Coll. no. 35911.

Original description.—

Test elongate, slender, about 4 times as long as broad, very gradually tapering from the broadly rounded initial end, often slightly curved; chambers distinct, increasing very gradually in size as added, the last few with the base crenulated; sutures distinct, slightly depressed in the later portion; wall ornamented in the earlier portion with very numerous, fine, somewhat anastomosing, longitudinal costae independent of the sutures, later portion becoming nearly smooth; aperture rounded, terminal, with a slender, cylindrical neck and slight lip. Length 1.00–1.25 mm.; diameter 0.25–0.30 mm.

RECTUVIGERINA LAMELLATA (Cushman)
Plate 83, figures 22, 23

Siphogenerina lamellata Cushman, 1918, U. S. Geol. Survey Bull. 676, p. 55, pl. 12, fig. 3.

Type locality.—One mile south of Red Bay, Florida.

Type specimen.—U. S. Nat. Mus., no. 325322.

Original description.—

Test elongate, tapering, gradually from the initial end, broadly rounded at the apertural end, chambers comparatively few, indistinct, surface ornamentation consisting of several equidistant, longitudinal lamellae extending from the initial end to the apertural end, where they fuse; aperture with a tubular neck and phialine lip. Length, 1 mm.

RECTUVIGERINA MAYI
(Cushman and Parker)
Plate 81, figures 8, 9

Siphogenerina mayi Cushman and Parker, 1931, Cushman Lab. Foram. Research Contr., vol. 7, pt. 1, p. 10, pl. 2, fig. 7.

Type locality.—Sec. 3, T. 28 S., R. 28 E., San Joaquin Valley, Calif.

Type specimen.—Cushman no. 14565.

Original description.—

Test elongate, tapering at the initial end, but the adult of fairly uniform diameter; chambers in the early portion irregularly triserial, later becoming uniserial, inflated, distinct; sutures distinct; wall ornamented by numerous, thin, platelike, longitudinal costae extending beyond the base of the chamber which is excavated, sometimes ending in slightly spinose projections; aperture nearly circular, at the end of a very short neck, with a distinct lip and usually with a platelike tongue in the opening itself. Length up to nearly 1.00 mm.; diameter 0.30–0.35 mm.

RECTUVIGERINA MULTICOSTATA
(Cushman and Jarvis)
Plate 82, figure 6

Siphogenerina multicostata Cushman and Jarvis, Cushman Lab. Foram. Research Contr., vol. 5, pt. 1, p. 14, pl. 3, fig. 6.

Type locality.—Cipero Section, Trinidad, B. W. I.

Type specimen.—Cushman no. 10056.

Original description.—

Test elongate, about 3 times as long as broad, early portion triserial, slightly tapering, whole test somewhat fusiform, greatest width at about the middle; chambers distinct, slightly inflated; sutures distinct, slightly depressed; wall ornamented with numerous longitudinal costae, not greatly raised and those of each chamber mostly independent of those of adjacent chambers, early chambers with distinct short spines not confluent with the later costae; aperture circular, with a cylindrical neck and wide thin lip. Length 0.80 mm.; breadth 0.27 mm.

RECTUVIGERINA NICOLI Mathews,
new species
Plate 81, figure 2

Uvigerina (*Sagrina*) *nodosa* d'Orbigny of Parker and Jones, 1865 (not *U. nodosa* d'Orbigny, 1826, Ann. Sci. Nat., Paris, Ser. 1, tome 7, p. 269), Royal Soc. London Philos. Trans., vol. 55, pp. 363–364, pl. 18, fig. 15.

?Sagrina nodosa ("Parker and Jones") Brady, 1884, Rept. Voyage Challenger, Zoology, vol. 9, pt. 5, p. 583, pl. 114, fig. 18.

Siphogenerina nodosa ("Parker and Jones") Thalmann, H. E., 1932, Eclogae geol. Helvetiae, vol. 25, p. 312.

Type locality.—Mediterranean.

Type specimen.—Repository not known.

Original description.—

Such a dimorphous condition [triserial and uni-

serial] is clearly seen in certain figures given by Soldani of Italian *Uvigerinae*, named *U. nodosa* by d'Orbigny; and we possess similar forms both from the recent and fossil deposits of the Mediterranean area, plate 18, fig. 15.

Remarks.—Specimens of Parker and Jones named *Uvigerina nodosa* D'Orbigny were misidentified. This is clear when Soldani's figures (upon which D'Orbigny based his species) are compared with the figure of Parker and Jones. Parker, Jones, and Brady, 1871, synonymized *U. nodosa* D'Orbigny, 1826, with *U. pigmea* D'Orbigny, 1826. Brady, 1884, figured a specimen which he called *Sagrina nodosa*, saying the name of D'Orbigny was being retained for the Parker and Jones form. Since Brady did not call this form a new species, instead erroneously crediting Parker and Jones with authorship, his usage is also incorrect. It is unfortunate that for a new species a holotype, which is poorly described and figured, must be chosen from literature. This is unavoidable since the species is rare and material containing specimens could not be found. The choice was either to let the species remain incorrectly labeled *nodosa* or erect a new species based upon the work of Parker and Jones. The latter course seemed better for the sake of nomenclatural correctness.

RECTUVIGERINA NODIFERA (Cushman and Kleinpell)
Plate 82, figure 20

Siphogenerina nodifera Cushman and Kleinpell, 1934, Cushman Lab. Foram. Research Contr., vol. 10, pt. 1, p. 13, pl. 2, figs. 15, 16.

Type locality.—Carneros Creek, California, 160 feet stratigraphically above base of Temblor formation.

Type specimen.—Holotype, Cushman no. 20141.

Original description.—

Test elongate, about 2½ times as long as broad, periphery somewhat lobate, triserial, except toward the apertural end; chambers distinct, inflated, last-formed one or two becoming terminal; sutures fairly distinct, depressed; wall ornamented by a few, 10–12, longitudinal costae, running the entire length of the test; aperture terminal, with a short neck. Length 1.20 mm.; diameter 0.50 mm. This species shows rather distinctly the development of *Siphogenerina* from *Uvigerina*, and the species is included in the former genus as it has the final chambers arranged in a uniserial manner.

RECTUVIGERINA NUCIFORMIS (Kleinpell)
Plate 83, figures 5, 6

Siphogenerina nuciformis Kleinpell, 1938, Miocene Stratigraphy of California, p. 303, pl. 15, figs. 10, 12.

Type locality.—L. S. J. U. locality 691, Reliz Canyon, Monterey County, Calif.

Type specimen.—Stanford University, holotype no. 5786, paratype no. 5787.

Original description.—

Test large, more than twice as long as broad, fusiform, typically peanut-like in shape and ornamentation; chambers distinct; sutures depressed, strongly curved and extending outward onto costae; wall ornamented by 11 or 12 lamellate, fairly low but strong thick costae which tend to be slightly interrupted by the sutures as in *S. branneri* rather than straight as in the other more closely related forms with high lamellate costae. Length, up to 1.48 mm.; breadth, up to 0.62 mm.

RECTUVIGERINA ONGLEYI (Finlay)
Plate 81, figure 18

Siphogenerina ongleyi Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, p. 111, pl. 13, figs. 42, 43.

Type locality.—Holotype loc. 5093, Porangahan, Wimbledon Rd., S. E. Surv. Dist., New Zealand.

Type specimen.—New Zealand Geol. Survey Coll.

Original description.—

Shell large and stout, microspheric form strongly tapering posteriorly to a point, megalospheric form almost cylindrical with blunt apex, lower half of both forms subcylindrical, narrowly truncate below, the aperture being situated in a shallow crater exactly as in *S. prisca*. Triserial portion very large, occupying about two-thirds of shell length; the chambers moderately inflated and separated by deep sutures. Uniserial chambers two or three at most, considerably staggered; whole shell covered with fine, close, low but fairly prominent axials, about twice their width apart. They are very regular in direction, and are crossed by a shallow groove posteriorly on each chamber to form a slight infrasutural shoulder of short, blunt points. These project more prominently near apex, which has numerous small spines.

Length, 1 mm.; width, 0.25 mm. (microspheric). Megalospheric form reaches 0.8 mm.

RECTUVIGERINA OPTIMA (Cushman)
Plate 82, figures 4, 5

Siphogenerina multicostata var. *optima* Cushman, 1943, Cushman Lab. Foram. Research Contr., vol. 19, pt. 4, p. 91, pl. 16, figs. 9, 10.

Type locality.—Fair Plain, Island of St. Croix, Virgin Islands.

Type specimen.—Cushman no. 39630.

Original description.—

Variety differing from the typical [*S. multicostata*] in the finer costae and the uniserial chambers which tend to be in an irregular line.

RECTUVIGERINA PANGGOEENSIS (Le Roy)
Plate 81, figure 5

Siphogenerina panggoeensis Le Roy, 1939, Natuurk. Tijdsch. voor Nederlandsch- Indië, 6e Aflevering van Deel 99, November, p. 252, pl. 8, fig. 11.

Type locality.—Aek Panggoe, 200 feet stratigraphically above base of Telisa Shale, Sumatra.

Type specimen.—Government Geological Museum, Bandoeng, Java, no. P. S. 1056a.

Original description.—

Test elongate, early stage triserial, later becoming biserial and in late stage irregularly uniserial, initial end pointed, fairly uniform in diameter throughout; chambers distinct, inflated; sutures distinct, depressed; wall ornamented by numerous, low longitudinal costae not extending beyond base of chamber; aperture nearly circular, at end of short, stout neck, sometimes with a slight lip. Length 0.70 mm.; thickenss 0.15 mm.

RECTUVIGERINA POHANA (Finlay)
Plate 82, figures 10, 11

Siphogenerina pohana Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, pp. 109–110, pl. 13, figs. 44, 45.

Type locality.—Loc. 3099, Uawa Surv. Dist., Poverty Bay, New Zealand, Poha formation.

Type specimen.—Holotype, New Zealand Geol. Surv. Coll.

Original description.—

Shell related to the previous species [*S. vesca* Finlay, 1941] but smaller and with very fine sculpture. Triserial part distinct, slightly bulbous, about one-fifth of total length, followed by 5 to 6 uniserial chambers about two-thirds to three-quarters as high as wide, lightly convex, sutures distinct but not deep, whole surface evenly covered with excessively fine and dense axials, not overrunning sutures . . . and visible only with a favourable light reflection. Apex with a very short single spine. Apertural tube relatively large and wide.

Length, 0.75 mm.; width, 0.12 mm.

RECTUVIGERINA POSTPRANDIA (Finlay)
Plate 82, figure 12

Siphogenerina postprandia Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, p. 108, pl. 13, figs. 40, 41.

Type locality.—Cormacks, New Zealand.

Type specimen.—Holotype, New Zealand Geol. Survey Coll.

Original description.—

A shell very similar to *striatissima* is abundant in the Kaiatan of Kakanui and Cormacks, but is considerable stouter, with more convex chambers and less acicular form, the ribbing being much weaker, especially in the sutures; uniserial chambers about five, lower ones almost smooth, apical spikes and plates much feebler. It may be called *Siphogenerina postprandia* n. sp., the holotype being from Cormacks and measuring 1 mm. by 0.2 mm. in size.

RECTUVIGERINA PRISCA (Finlay)
Plate 81, figure 19

Siphogenerina prisca Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, p. 110, pl. 13, figs. 48–51.

Type locality.—Hampden Section (loc. 5179A), New Zealand.

Type specimen.—Holotype, New Zealand Geol. Surv. Coll.

Original description.—

Shell small, with a disproportionately large triserial part, and few uniserial chambers, with inconspicuous ribs. Surface smooth and glossy between ribs, chambers inflated, especially the Uvigerine ones, separated by fairly deep sutures. Uniserial chambers usually only two, never more than three. Axial ribs thin and delicate, very little raised, numerous but several times their width apart, discontinuous across sutures, produced into little spikes on apex, subobsolete on uniserial chambers, absent on base, which rather flatly and narrowly truncates the globular last chamber, the aperture being a small rimmed tube in the depression. The whole impression is that of a juvenile *Uvigerina pigmea* with a couple of extra staggered cylindrical chambers.

Length, 0.6 mm.; width, 0.2 mm.

RECTUVIGERINA PSEUDOCOCOAENSIS
(Cushman and Kleinpell)
Plate 82, figures 18, 19

Siphogenerina pseudococoaensis Cushman and Kleinpell, 1934, Cushman Lab. Foram. Research Contr., vol. 10, pt. 1, p. 13, pl. 2, fig. 14.

Type locality.—Carneros Creek, California.

Type specimen.—Holotype, Cushman no. 20143.

Original description.—

Test elongate, slender, increasing in diameter in the earliest portion, then keeping the same diameter, or even reducing this in the adult; chambers distinct, somewhat inflated, nearly all loosely spiral, last one or two uniserial, more inflated; sutures fairly distinct, somewhat depressed; wall ornamented in the earliest portion by numerous longitudinal costae, four or six visible in the side view, independent of the chambers, becoming obsolescent on the uniserial chambers; aperture in the adult terminal, circular, with a slight neck. Length 1.00 mm. or more; diameter 0.35 mm. Adults often have one more chamber than that shown in the type figure.

RECTUVIGERINA REEDI (Cushman)
Plate 83, figure 16

Siphogenerina reedi Cushman, 1925, Cushman Lab. Foram. Research Contr., vol. 1, no. 2, p. 3, pl. 4, fig. 4.

Type locality.—Sec. 24, T. 28 S., R. 14 E., San Luis Obispo County, Calif.

Type specimen.—Cushman no. 4236.

Original description.—

Test about twice as long as broad, greatest breadth at the apertural end, thence gradually tapering to the initial end; chambers distinct; sutures somewhat depressed, strongly curved; wall ornamented with about fifteen lamellate costae which may continue onto the last formed chamber; apertural characters obscure. Length up to 1.10 mm.; breadth 0.50 mm. It is the nearest form I have described from the Panama Canal Zone as *S. raphanus* (Parker and Jones) var. *transversus* Cushman.

RECTUVIGERINA RERENSIS (Finlay)
Plate 82, figure 15

Uvigerina tenuistriata Reuss of Chapman, 1926, New Zealand Geol. Survey, Pal. Bull., no. 11, pl. 14, fig. 9; (not *U. tenuistriata* Reuss, 1870).
Siphogenerina rerensis Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, p. 110, pl. 11, fig. 8.

Type locality.—Whangara Beach, Poverty Bay, New Zealand, Hutchinsonia.

Type specimen.—New Zealand Geol. Surv. Coll.

Original description.—

Shell generally similar to *striatissima* and of the same size, but with notably longer and fewer chambers. Those of *striatissima* are oblong, about half as high as wide, with markedly curved sides. There are never more than five, usually four uniserial ones; the triserial part is much less hidden by sculpture, the Uvigerine chambers distinctly convex and noticeable, forming a somewhat bulbous apex to shell (about one-quarter of total length). Ribs are very similar but more distant, about twice their width apart, produced into the same irregular spines posteriorly (though these tend to coalesce more into one long and strong spine), of even strength over whole shell, not diminishing on last chamber or base. Aperture relatively longer and wider, with a rim and one or two concentric ridges.

Length, 1 mm.; width, 0.2 mm.

RECTUVIGERINA SENNI (Cushman and Renz)
Plate 83, figures 12–14

Siphogenerina senni Cushman and Renz, March, 1941, Cushman Lab. Foram. Research Contr., vol. 17, pt. 1, p. 22, pl. 3, figs. 21, 22.
Siphogenerina yumuriana Palmer, July, 1941, Soc. cubana hist. nat. Mem., vol. 15, pt. 4, p. 185, pl. 15, figs. 3, 4. (Palmer Coll. types no. 18–61; type loc. Palmer Sta. 378 base, Cojimar formation, Cuba.)

Type locality.—Isidro, Dist. Zamura, State Falcon, Venezuela.

Type specimen.—Holotype, Cushman no. 35912.

Original description.—

Test elongate, 3½–4 times as long as broad, tapering in the microspheric form, nearly cylindrical in the megalospheric, rounded in transverse section; chambers distinct except in the earliest portion, little if at all inflated, of uniform size and shape in the adult, slightly overlapping; sutures distinct in the later portion, slightly if at all depressed; wall ornamented with 8–10 longitudinal, plate-like costae, continuous from the initial end to the base of the last-formed chamber which is smooth, often projecting at the base of the test; aperture terminal, rounded with a tubular neck and slight lip. Length 0.80–1.10 mm.; diameter 0.25–0.30 mm.

RECTUVIGERINA SMITHI (Kleinpell)
Plate 82, figures 16, 17

Siphogenerina Smith, 1930, Micropaleontology Bull., vol. 2, no. 1, p. 7.
Siphogenerina smithi Kleinpell, 1938, Miocene stratigraphy of California, p. 304, pl. 6, figs. 1, 2.

Type locality.—3162 feet, Doty well no. 4, Elwood oil field, Santa Barbara County, Calif.

Type specimen.—Stanford University, holotype no. 6109; paratype, no. 6110.

Original description.—

Test large, fusiform, much longer than broad; chambers moderately inflated, triserial through more than two-thirds of the test, later chambers uniserial; sutures distinct to somewhat indistinct in more ornate forms, depressed; surface covered with numerous moderately strong longitudinal and more or less discontinuous costae which if

not discontinuous are generally notched at the sutures; aperture central, terminal, on short neck.

This primitive and raggedly ornate *Siphogenerina* appears to be a siphogenerine development from *Uvigerinella sparsicostata* Cushman and Laiming. Its irregular costae distinguish it from *S. nodifera* Cushman and Kleinpell and the triserial arrangement of the early and middle stages of the test distinguish it from other Siphogenerinas. The costae are fewer and much more coarse, and the whole test stouter, than in *S. mayi* Cushman and Parker.

RECTUVIGERINA SPINOSA (Bagg)
Plate 83, figure 4

Sagrina spinosa Bagg, 1904, Maryland Geol. Survey (Miocene), p. 480, pl. 133, fig. 11.
Siphogenerina spinosa (Bagg) Cushman, 1918, U. S. Geol. Survey Bull. 676, p. 55.

Type locality.—Jones Wharf, Governor Run, Maryland.

Type specimen.—Maryland Geol. Surv. Coll.

Original description.—

This peculiar and interesting species somewhat resembles *S. raphanus* Parker and Jones, but differs from the latter in several particulars. The surface ridges in our specimen end in a series of projecting points which at the distal end become definite spines, though these are short and stubby. Again there are arched cross ridges between these costae which while they may not indicate the internal structure of the chambers serve to mark their location. The aperture ends in a neatly raised phialine everted lip with central rounded orifice.

RECTUVIGERINA STRIATA (Schwager)
Plate 81, figures 3, 4

Dimorphina striata Schwager, 1866, Novara Exped., Geol. Theil., vol. 2, p. 251, pl. 7, figs. 2, 99.
Siphogenerina striata (Schwager) Cushman, 1939, Geol. Soc. Japan Jour., vol. 46, no. 546, p. 152, pl. 10, fig. 9.
Siphogenerina striata (Schwager) Le Roy, 1941, Colorado School of Mines Quart., vol. 36, no. 1, pt. 1, p. 37, pl. 3, figs. 88, 89.
Not *Sagraina striata* (Schwager) Brady, 1884, Rept. Voyage Challenger, vol. 9, p. 584, pl. 75, figs. 25, 26.
Not *Siphogenerina striata* (Schwager) Cushman, 1913, U. S. Nat. Museum Bull., 71, pt. 3, p. 107, pl. 47, figs. 4, 5.

Type locality.—Kar Nicobar, British India.

Type specimen.—Repository not known.
Original description.—Free translation.

Test elongate, for the most part nodosarian; initial chambers, however, spirally formed, which arrangement is often omitted, with biserial first and then uniserial. The first few chambers are noticeably broader than tall, later rather arched with sides rounded, rapidly sloping toward the deep, sharp sutures; final chamber flat on top with a thin apertural tube flaring at the end. On the bottom of the initial chamber a short, thin spine is often present; over the whole test run fine, dense, thread-like ribs, separated equally, which run near the bottom where the spine is often detached. The shell wall is thin, glassy, with very fine and dense radial pores; if the bottom part is spiny, the spine sinks into the test as a peg; length, 0.9 mm.

Remarks.—This species shows a well-defined, though small, triserial neanic stage which Schwager refers to as spiral.

RECTUVIGERINA STRIATISSIMA (Stache)
Plate 82, figure 9

Nodosaria striatissima Stache, var. a, b, c, d, e, and f, Stache, 1865, Reise der Novara, Pal., vol. 1, p. 198, pl. 22, fig. 25.
Siphogenerina striatissima (Stache) of Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, pp. 106, 107.

Type locality.—Whaingaroa beds, New Zealand.

Type specimen.—Repository not known.
Original description.—Free translation.

Thin, very delicate curved form with, as a rule, eight moderate, horizontal, suture lines separating gradually as the chambers grow larger. The last chamber is not compressed, but rather somewhat constricted and delicately sloping laterally. It runs into a thin, smooth neck which itself again runs into a small, circular, bowl-shaped, compressed and extended lip. The lowest chambers have a narrow, glassy ridge on two sides, which extends into a three-pointed spine toward the bottom. Length, 1.08 mm., width 0.20 mm.

Remarks.—Stache figured six varieties. His figure of var. *alpha* is reproduced here as being representative of ths species. The early portion of Stache's figure is idealized.

RECTUVIGERINA TENUA
(Cushman and Kleinpell)
Plate 83, figures 8, 9

Siphogenerina tenua Cushman and Kleinpell, 1934, Cushman Lab. Foram. Research Contr., vol. 10, pt. 1, p. 13, pl. 2, fig. 13.

Type locality.—Carneros Creek, California.

Type specimen.—Holotype, Cushman no. 20140.

Original description.—

Test very long, slender, about four times as long

as broad; chambers rather high, somewhat indistinct; sutures obscured by the ornamentation of the surface; wall ornamented by numerous, long, raised costae, about ten in number, with smaller intermediate costae, towards the apertural end, final chamber smooth; aperture rounded, terminal, with a very short neck. Length 2.00 mm.; diameter 0.50 mm.

RECTUVIGERINA TRANSVERSA (Cushman)
Plate 83, figure 7

Siphogenerina raphanus var. *transversus* Cushman, 1918, U. S. Nat. Museum Bull., no. 103, p. 64, pl. 22, fig. 8.

Type locality.—U. S. Geol. Survey Sta. 6010, north of Pedro Miguel Locks to Paraiso Bridge, Panama Canal Zone.

Type specimen.—U. S. Nat. Museum no. 324646.

Original description.—

Test subcylindrical, composed of comparatively few chambers, the earlier ones spirally arranged, later and greater portion of the test uniserial, sutures very prominently indented, between the longitudinal costae, aperture with a short cylindrical neck. Length, 1.24 mm.; diameter, 0.54 mm.

RECTUVIGERINA VESCA (Finlay)
Plate 81, figure 7

Siphogenerina vesca Finlay, 1939, Royal Soc. New Zealand Trans., vol. 69, pt. 1, p. 109, pl. 13 figs. 46, 47.

Type locality.—Citrini's Area, loc. 5105, near Kumara, Greymouth; Hutchinsonian, New Zealand.

Type specimen.—New Zealand Geol. Survey Coll.

Original description.—

In the South Island Hutchinsonian a closely related [to *S. rerensis* Finlay, 1939] but distinct species replaces it; this has the same general separative features from *striatissima* in the distinct Uvigerine portion, regular and persistent ribbing and convex chambers, and differs from *rerensis* only in smaller size, still more distinct and convex chambers, the end ones tending to become globular and separated, and the more numerous finer and lower ribs, erecially posteriorly, where the triserial part (about one-third of length), instead of being more strongly and spikily sculptured is actually smoother, with the ribs twisting into a single terminal spike. This form may be called *Siphogenerina vesca* . . . .

On the evidence, both *rerensis* and *vesca* seem to be characteristic Hutchinsonian species; both are related to the Trinidad Oligocene *multicostata* Cushman and Jarvis, 1929, especially the former, but have ribs interrupted much more by sutures, not continuous over shell.

DIVISION INTO SUBGENERA

The wide range in ornamentation and test form among species of *Rectuvigerina* justifies a subdivision of the genus. This is further encouraged by the manner in which the genus may be divided into two natural subgeneric groups. One of the subgenera (*Transversigerina*) has a limited geologic range, which will enable field geologists to employ it in stratigraphic correlations where immediate specific identification would be impossible. The following proposed subgenera are listed with their subgenotypes and species.

RECTUVIGERINA, s.s., n. subgen.

Subgenotype.—*Rectuvigerina* (*Rectuvigerina*) *multicostata* (Cushman and Jarvis, 1929).

Description of subgenus.—Test like *Uvigerina* with uniserial chambers added; sutures straight in uniserial portion; costae very weak to strong, numerous, continuous or discontinuous over sutures, often anastomosing into basal spines.

1. *Rectuvigerina* (*Rectuvigerina*) *basispinata* (Cushman and Jarvis, 1929).
2. *R.* (*R.*) *costostriata* (Galloway and Heminway, 1941).
3. *R.* (*R.*) *fredsmithi* (Garrett, 1939).
4. *R.* (*R.*) *hubbardi* (Galloway and Heminway, 1941).
5. *R.* (*R.*) *hughesi* (Cushman, 1925).
6. *R.* (*R.*) *irregularis* (Bagg, 1908).
7. *R.* (*R.*) *mayi* (Cushman and Parker, 1931).
8. *R.* (*R.*) *multicostata* (Cushman and Jarvis, 1929).
9. *R.* (*R.*) *nicoli* Mathews, n. sp.
10. *R.* (*R.*) *nodifera* (Cushman and Kleinpell, 1934).
11. *R.* (*R.*) *ongleyi* (Finlay, 1939).
12. *R.* (*R.*) *optima* (Cushman, 1943).
13. *R.* (*R.*) *panggoeensis* (Le Roy, 1939).
14. *R.* (*R.*) *pohana* (Finlay, 1939).
15. *R.* (*R.*) *postprandia* (Finlay, 1939).
16. *R.* (*R.*) *prisca* (Finlay, 1939).
17. *R.* (*R.*) *pseudococoaensis* (Cushman and Kleinpell, 1934).
18. *R.* (*R.*) *rerensis* (Finlay, 1939).
19. *R.* (*R.*) *smithi* (Kleinpell, 1938).
20. *R.* (*R.*) *striata* (Schwager, 1866).
21. *R.* (*R.*) *striatissima* (Stache, 1865).
22. *R.* (*R.*) *vesca* (Finlay, 1939).

TRANSVERSIGERINA Mathews, n. subgen.

Subgenotype.—*Rectuvigerina* (*Transversisigerina*) *transversa* (Cushman, 1918).

Description of subgenus.—Species distinguished by arched sutures[1] between costae; sutures vary from crescent-shaped pits to broadly rounded arches; costae continuous over sutures.

Remarks.—Some species of the subgenus (*R. kugleri*) show straight juvenile sutures and curved gerontic sutures, indicating derivation of the group from *Rectuvigerina, sensu stricto.*

1. *Rectuvigerina* (*Transversigerina*) *branneri* (Bagg, 1905).
2. *R.* (*T.*) *collomi* (Cushman, 1925).
3. *R.* (*T.*) *cubensis* (Cushman and Bermudez, 1937).
4. *R.* (*T.*) *cumingsi* (Galloway and Heminway, 1941).
5. *R.* (*T.*) *kleinpelli* (Cushman, 1925).
6. *R.* (*T.*) *kugleri* (Cushman and Renz, 1941).
7. *R.* (*T.*) *lamellata* (Cushman, 1918).
8. *R.* (*T.*) *nuciformis* (Kleinpell, 1938).
9. *R.* (*T.*) *reedi* (Cushman, 1925).
10. *R.* (*T.*) *senni* (Cushman and Renz, 1941).
11. *R.* (*T.*) *spinosa* (Bagg, 1904).
12. *R.* (*T.*) *tenua* (Cushman and Kleinpell, 1934).
13. *R.* (*T.*) *transversa* (Cushman, 1918).

ILLUSTRATED KEY

KEY TO SUBGENERA OF RECTUVIGERINA

Sutures arched between costae (pl. 83, fig. 3) ..... *Transversigerina*
Sutures not arched betwen costae (pl. 82, fig. 3) ..... *Rectuvigerina, s. s.*

KEY TO SPECIES OF RECTUVIGERINA, *sensu stricto*

1 Uniserial part in adult at least ½ length. 2
Uniserial part in adult rarely over ½ length, never as much as ½ 16
2 (1) Apertural neck inset, like stem of apple ..... *irregularis* (pl. 81, fig. 15)
Apertural neck not inset 3
3 (2) Width about ½ length or less 4
Width about 2/7 length or less 10
4 (3) Basal spine or spines present 5
Without basal spines ..... *panggoeensis* (pl. 81, fig. 5)
5 (4) Basal spines numerous, weak; costae sparse, weak, especially near sutures. ..... *postprandia* (pl. 82, fig. 12)
Basal spines few, usually in form of terminal peg or spike; costae dense 6
6 (5) Single basal spike 7
Typically more than one basal spike ..... *striatissima* (pl. 82, fig. 9)
7 (6) Apertural neck with concentric ridges. ..... *rerensis* (pl. 82, fig. 15)
Apertural neck without ridges 8
8 (7) Apertural neck very thin, tall with flaring lip ..... *striata* (pl. 81, figs. 3, 4)
Apertural neck not thin, without flaring lip 9
9 (8) Costae very fine, dense, not easily visible ..... *pohana* (pl. 82, figs. 10, 11)
Costae distinct ..... *vesca* (pl. 81, fig. 7)
10 (3) Aperture with plate-like tongue ..... *mayi* (pl. 81, figs. 8, 9)
Aperture without tongue 11
11(10) Test smooth or with striae visible only under favorable lighting ..... *hughesi* (pl. 82, figs. 1, 2)
Test with costae 12
12(11) Costae continuous over sutures 13
Costae discontinuous over sutures 14
13(12) Basal spines present ..... *basispinata* (pl. 82, figs. 13, 14)
Basal spines absent ..... *hubbardi* (pl. 82, fig. 3)
14(12) Costae sparse ..... *fredsmithi* (pl. 81, fig. 6)
Costae dense 15
15(14) Uniserial chambers staggered; costae fine ..... *optima* (pl. 82, figs. 4, 5)
Uniserial chambers straight; costae coarse ..... *multicostata* (pl. 82, fig. 6)
16 (1) Striae between costae; uniserial chambers oval in cross section ..... *costostriata* (pl. 82, figs. 7, 8)
No striae between costae; uniserial chambers round in cross section 17
17(16) Costae very fine, dense ..... *nicoli* (pl. 81, fig. 2)
Costae coarse, sparse 18
18(17) Last chamber smooth ..... *pseudococoaensis* (pl. 82, figs. 18, 19)
Last chamber with costae 19
19(18) Costae continuous over whole length of test ..... *nodifera* (pl. 82, fig. 20)
At least some costae not continuous over whole length of test 20
20(19) Costae interrupted by sutures; basal spines present 21
At least some costae continue over sutures; no spines present ..... *smithi* (pl. 82, figs. 16, 17)
21(19) Costae subobsolete on uniserial chambers ..... *ongleyi* (pl. 81, fig. 18)
Costae undiminished on uniserial chambers ..... *prisca* (pl. 81, fig. 19)

[1] Although these arched lines are called sutures and mark the position where the septa are attached to the test, they do not indicate crenulated septa within as in the case of ammonites.

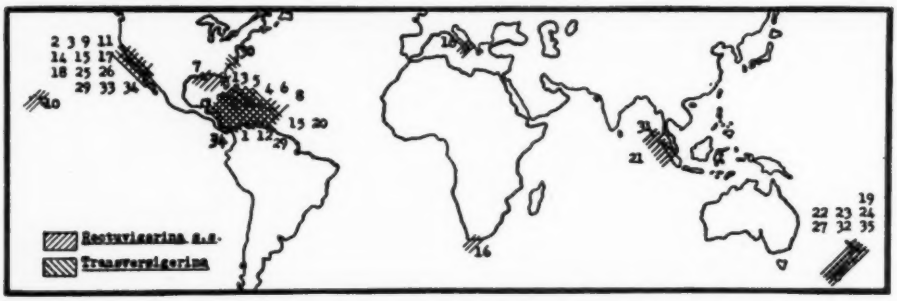

FIG. *1*—World distribution of *Rectuvigerina, s. l.* Numbers correspond to the following species: 1. *basispinata*, 2. *branneri*, 3. *collomi*, 4. *costostriata*, 5. *cubensis*, 6. *cumingsi*, 7. *fredsmithi*, 8. *hubbardi*, 9, *hughesi*, 10, *irregularis*, 11. *kleinpelli*, 12, *kugleri*, 13. *lamellata*, 14. *mayi*, 15. *multicostata*, 16. *nicoli*, 17. *nodifera*, 18. *nuciformis*, 19. *ongleyi*, 20. *optima*, 21. *panggoeensis*, 22. *pohana*, 23. *postprandia*, 24. *prisca*, 25. *pseudococoaensis*, 26. *reedi*, 27. *rerensis*, 28. *senni*, 29, *smithi*, 30. *spinosa*, 31. *striata*, 32. *striatissima*, 33. *tenua*, 34. *transversa*, 35. *vesca*.

KEY TO SPECIES OF TRANSVERSIGERINA

1 Sutures straight between costae in early part of test, crenulated in later part; numerous fine costae present..... .....*kugleri* (pl. 83, figs. 20, 21)
Sutures arched between costae in early part of test; without numerous fine costae.....2

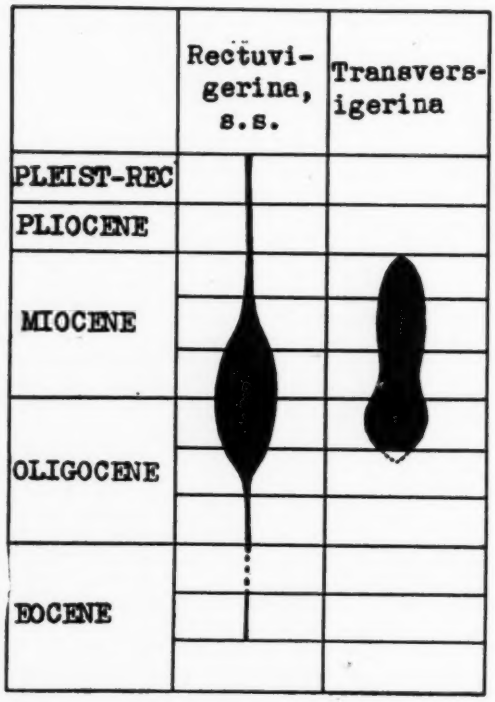

FIG. *2*—Time distribution of the subgenera of *Rectuvigerina*, showing range and abundance.

2 (1) At least 14 rows of costae present.....3
Less than 14 rows of costae present....5
3 (2) Costae high; sutures acutely arched... .....*reedi* (pl. 83, fig. 16)
Costae low; sutures roundly arched....4
4 (3) Usually not less than 16 rows of costae present; maximum length about 1.60 mm...*branneri* (pl. 83, figs. 17, 18, 19)
Not more than 15 rows of costae present; maximum length about 1.00 mm.... .....*kleinpelli* (pl. 83, fig. 15)
5 (2) Microspheric form 3½ to 4 times as long as broad.....6
Microspheric form less than 3 times as long as broad.....8
6 (5) Costae high; maximum length at least 1.00 mm.....7
Costae low, 7 or 8 rows; secondary costae near base in megalospheric form; maximum length under 1.00 mm..... .....*cumingsi* (pl. 83, figs. 2, 3)
7 (6) Apertural neck low; sometimes intermediate costae near apertural end; maximum length of microspheric form about 2.00 mm.....*tenua* (pl. 83, figs. 8, 9)
Apertural neck conspicuous; no intermediate costae; maximum length of microspheric form about 1.10 mm... .....*senni* (pl. 83, figs. 12, 14)
8 (5) About 7 rows of lamellate costae present .....*lamellata* (pl. 83, figs. 22, 23)
More than 8 rows of costae present or costae not lamellate.....9
9 (8) Costae projecting into short basal spines .....*spinosa* (pl. 83, fig. 4)
No basal spines present.....10
10 (9) Costae high, often lamellate.....11
Costae low, never lamellate.....13
11(10) Maximum length about 1.60 mm..... .....*collomi* (pl. 83, fig. 1)
Maximum length not over 1.40 mm...12
12(11) Adult test fusiform..... .....*cibensis* (pl. 83, figs. 10, 11)
Adult test nearly cylindrical..... .....*transversa* (pl. 83, fig. 7)

13(10) Sutures strongly curved, extending onto costae. . . . ***nuciformis*** (pl. 83, figs. 5, 6)
Sutures slightly curved, not extending onto costae. . ***kleinpelli*** (pl. 83, fig. 15)

GEOGRAPHIC DISTRIBUTION

The genus *Rectuvigerina* is of world-wide distribution, but centers of great abundance of species are confined to three areas, the Caribbean Sea, California, and New Zealand. The Caribbean center extends north through the Gulf of Mexico to Texas, Louisiana, and Florida with the northernmost occurrence of the genus in Maryland, and extends south along the northern coast of South America and west to Panama and Central America. In California species of the genus are numerous in many Miocene and Oligocene sections, especially in the southern portion. Some of the same species (see text fig. 1) are also present in the Caribbean area and permit age correlation between the two regions. New Zealand has only representatives of the subgenus *Rectuvigerina, s. s.*, and none of these species are present in California or the Caribbean area. The Recent Hawaiian *irregularis* shows a close relationship to *ongleyi* and *prisca* of New Zealand in the depression surrounding the apertural neck and probably represents a continuation of the *ongleyi, prisca* line (Finlay, 1939, p. 112). Further comparisons show resemblances between *multicostata*, present both in California and the Caribbean area, and many of the New Zealand forms, but evidence supporting specific lineage is not conclusive.

GEOLOGIC DISTRIBUTION

The earliest occurrence of *Rectuvigerina* in strata which can be safely correlated with European stages is *R. prisca*, of the Bortonian (middle Eocene) of New Zealand. Apparently this represents the only Eocene occurrence of the genus. *Rectuvigerina* is sparsely represented through lower and middle Oligocene strata but becomes abundantly represented in the upper Oligocene. Culmination of the genus from the standpoint of number of species was probably at the close of the Oligocene (Zemorrian, Saucesian in California).

A glance at text figure 3 shows that, while *Rectuvigerina, sensu stricto*, ranges from Eocene to Recent, *Transversigerina* is a valuable time indicator—upper Oligocene and Miocene. *Transversigerina* may be recognized by using a 20 power hand lens with which it is possible to see the arched sutures, characteristic of the subgenus.

RELATIONSHIPS OF RECTUVIGERINA

Morphologic similarity and close phylogenetic relationship of certain genera to *Siphogenerina*, as formerly conceived, caused various writers to shift species from one genus to another. These so-called "related" groups included at least eight genera distributed in two families. Such confusion suggests that the genus concerned includes unrelated forms. Separation of *Rectuvigerina* from other groups, however, requires a short discussion of only three genera, two because of common phylogeny and a third because of isomorphism.

Sagrina (type, *S. pulchella*, d'Orbigny, 1839), which has contained at some time many of the species now assigned to *Rectuvigerina*, need not be considered here. The genotype shows a close affinity to *Bolivina* (type, *B. plicata* d'Orbigny, 1839) and may, indeed be considered a part of that genus (Cushman, 1926a, p. 2).

Family UVIGERINIDAE Galloway and Wissler, 1927

Subfamily UVIGERININAE Cushman, 1913

Genus UVIGERINA, d'Orbigny, 1826

Plate 81, figure 20

Genotype.—*Uvigerina pigmea* d'Orbigny, 1826, Ann. Sci. Nat., Paris, ser. 1, tome 7, p. 268, pl. 12, figs. 8, 9.

Original description of genotype.—Translation.

Shell oval-oblong, swollen anteriorly, acuminate posteriorly, ornamented lengthwise by prominent ribs interrupted at each chamber, which are swollen unequally, the final one, more swollen than the others is provided with an aperture which is bordered all around. This pretty species is distinguished easily from the others by its small size and by its prominent and very pronounced ribs.

The distinction between *Rectuvigerina* and *Uvigerina* is difficult since the former was derived from the latter. Differences between these genera may be listed in two comparisons: (1) *Rectuvigerina* has one or more uniserial chambers; *Uvigerina* is triserial

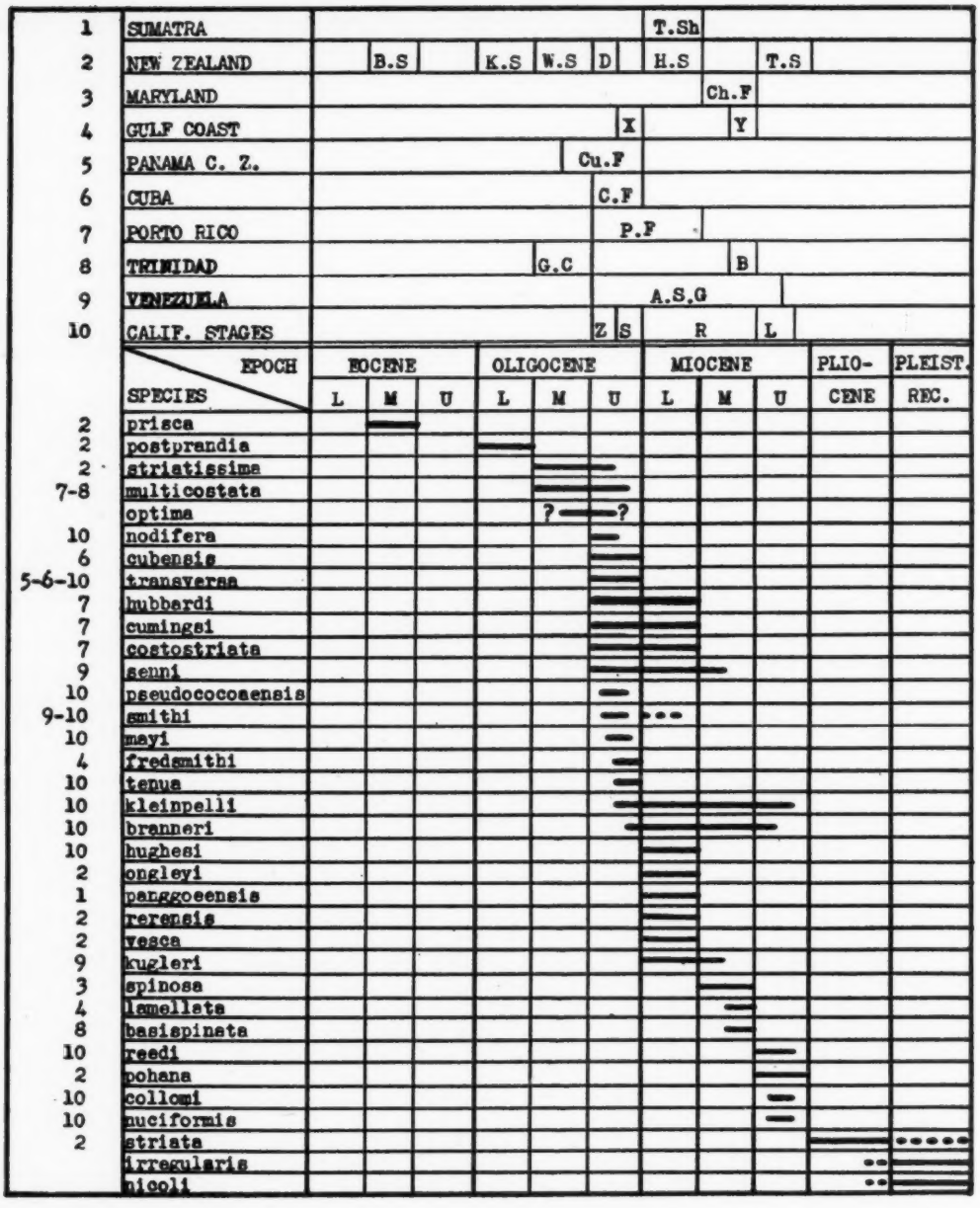

FIG. 3—Time distribution of the species of *Rectuvigerina*. Numbers beside specific names refer to corresponding numbers beside geographic localities above. Unnumbered species are either Recent, as *irregularis* and *nicoli*, or from subsurface strata of unknown time relationships, as *optima*. Lettered sections opposite localities refer to group, formational, or stage names. These sections are correlated with the European time scale below, with abbreviations as follows:

A.S.G.	Agua Salada Group	P.F.	Ponce Formation
B	"*Sagrina* Beds"	R	Relizian Stage
B.S.	Bortonian Stage	S	Saucesian Stage
C.F.	Cojimar Formation	T.S.	Taranakian Stage
Ch.F.	Choctawhatchee Formation	T.Sh.	Telisa Shale
Cu.F.	Culebra Formation	W.S.	Whaingaroan Stage
D	Duntroonian Stage	X	*Discorbis* Zone
G.C.	"Green Clay"	Y	*Arca*, *Siphogenerina lamellata*, *Uvigerina lirrettensis* Zones
H.S.	Hutchinsonian Stage		
K.S.	Kaitan Stage		
L	Luisian Stage	Z	Zemorrian Stage

throughout. (2) *Rectuvigerina* has an internal siphon; *Uvigerina* has not. Where such simple changes of structure represent the only observable differences between groups, they may be repeated independently at different geologic intervals. Thus, species of *Rectuvigerina* have arisen from different species of *Uvigerina* during different geologic ages. Since *Uvigerina* is confused with *Rectuvigerina* especially when specimens of *Rectuvigerina* are in their youthful stage before the addition of uniserial chambers, a specimen in this stage must be placed generically by sectioning to determine the presence of an internal tube.

There are some species now assigned to *Uvigerina* which show characteristics of both *Uvigerina* and *Rectuvigerina*. Until further evidence indicates definitely in which genus these forms should be placed, it is thought advisable to leave them where originally assigned. Some of these forms are listed below:

1. *U. bifurcata* d'Orbigny, 1839.
2. *U. boniensis* Forasini, 1888, of Macfadyen, 1930.
3. *U. peregrina* var. *bradyana*, Cushman, 1923.
4. *U. longa* var. *denticosta*, Cushman and Bermudez, 1937.
5. *U. israelskyi* Garrett, 1939.
6. *U. longa* Cushman and Bermudez, 1937.
7. *U. peregrina* Cushman, 1923.
8. *U. schwageri* Brady, 1884.
9. *U. seriata* Cushman and Jarvis, 1929.
10. *U. spinicostata* Cushman and Jarvis, 1929.
11. *U. tenuistriata* Reuss, 1870.

Genus UVIGERINELLA Cushman, 1926
Plate 81, figure 1

Genotype.—*U. californica* (Cushman, 1926), Contr. Cushman Lab. Foram. Res., vol. 1, pt. 3, no. 30, p. 58, pl. 8, figs. 2, 5.

Original description of genus.—

The species here referred to *Uvigerina* are characterized by a peculiar set of apertural characters. Instead of a definite tubular neck there is an elevated "collar" about the aperture, the inner sides of which often do not meet but run down the sides of the test about the aperture. The aperture itself instead of being circular as in typical *Uvigerina* is elliptical and has usually a valvular tooth. This seems to be a unique development in this particular region in the Miocene. This type species is *Uvigerina* (*Uvigerinella*) *californica* Cushman, n. sp.

Original description of genotype.—

Test much longer than broad, greatest breadth near the apertural end, composed of 6 or 7 whorls; chambers distinct, inflated, 3 in each whorl, arranged in longitudinal series but slightly twisted so that each vertical series makes about ¼ turn of the test, last-formed chamber often slightly irregular; sutures distinct, depressed; wall smooth, finely perforate; aperture with a very short neck, not cylindrical, but somewhat compressed, from the inner portion of the chamber a very slight phialine lip, and in some specimens apparently an apertural tooth, thin, plate-like, projecting in from the inner side of the aperture. Length up to 1 mm.; breadth 0.30 mm. Holotype (Cushman Coll. No. 5739).

A discussion of this genus is necessary because species of *Rectuvigerina* seem to have been derived from this genus as well as from *Uvigerina*. *Uvigerinella sparsicostata* Cushman and Laiming, 1931, appears to be the direct ancestor of *Rectuvigerina smithi* (Kleinpell, 1938, p. 304). H. H. Renz (personal communication Oct. 16, 1944) has found that it is very difficult to distinguish between these species in the Agua Salada group, Trinidad.[1] It seems reasonable that other species of *Rectuvigerina* with apartural peculiarities, such as *R. mayi*, might also have had a *Uvigerinella* ancestor. Kleinpell, however, cautions (1938, p. 287):

"The apertural characters distinctive of this subgenus [*Uvigerinella*] appear to be somewhat variable, even in well preserved material, much of which seems indistinguishable from *Uvigerina, sensu stricto*. Most of the material available for comparative study, however, particularly the subsurface material, is not in the best state of preservation. The apertural lip is often completely broken away, and much of the neck also, rendering definite recognition of the subgenus, as such, extremely hazardous."

Family HETEROHELICIDAE Cushman, 1927
Subfamily BOLIVINITINAE Cushman, 1927
Genus SIPHOGENERINOIDES Cushman, 1927
Plate 81, figures 10, 11

Genotype.—*S. plummeri* (Cushman, 1926), U. S. Nat. Museum Proc. no. 2597, vol. 67 (1925), art. 25, p. 18.

[1] In a later communication (Dec. 16, 1944) H. H. Renz reported the presence of a siphon in *U. sparsicostata*. If this structure is considered more important than apertural form, this species would be better placed in *Rectuvigerina*.

Original description of genus.—

Test in the early stages biserial, later uniserial, aperture with a neck and phialine lip; without siphons between the chambers.

Original description of genotype.—

Test small elongate, 3½ to 4 times as long as broad, very slightly tapering, greatest width developed by the last formed chamber. Early chambers biserial, later ones, which make the bulk of the test, uniserial, circular in transverse section; chambers distinct, slightly inflated; sutures distinct and depressed, especially in the uniserial portion; surface ornamented by about 8 longitudinal costae, sharp, and the posterior angles tending to project slightly in almost spinose angles, the last-formed chambers tending to develop supplementary costae between the primary ones, initial end of the test spinose formed by the ends of the costae; aperture elliptical with distinct lip and very short neck. Length up to 0.65 mm.; diameter 0.25–0.30 mm.

The Cretaceous genus *Siphogenerinoides* contains many forms closely resembling species of the post-Cretaceous *Rectuvigerina*. Some forms have an internal tube connecting the chambers (*Siphogenerinoides clarki* Cushman and Campbell, 1936) as in *Rectuvigerina;* others, including the genotype, are apparently without this structure. This important difference in anatomy incorporated within the same genus suggests a poorly defined group. It seems probable that some species brought together in the genus are, in reality, not closely related. Species assigned to *Siphogenerinoides* may have a triserial neanic stage, a biserial one, or in the megalospheric form, may be uniserial throughout. Also, members of this group may have phialine lips or arched sutures as do some species of *Rectuvigerina*.

Distinguishing features between the genera may be summarized in the following manner: (1) *Siphogenerinoides* may have a serrate aperture; *Rectuvigerina* never does. (2) *Siphogenerinoides* usually has a biserial neanic stage; *Rectuvigerina* always a triserial one. (3) *Siphogenerinoides* usually has no internal siphon; *Rectuvigerina* always does.

ACKNOWLEDGMENTS

Special thanks are due to Hubert G. Schenck and A. Myra Keen of Stanford University for guidance and criticism in the preparation of this paper. Helpful suggestions and assistance were also given by H. H. Renz of Trinidad, particularly on the *Siphogenerina-Siphogenerinoides* problem. Thanks are also due to Harry S. Ladd of the U. S. G. S. and Edward Hoffmeister of the University of Rochester for their supply of topotype material, and to Brooks F. Ellis of the American Museum of Natural History for information about the nomenclature of *Siphogenerina nodosa* (Parker and Jones, 1865).

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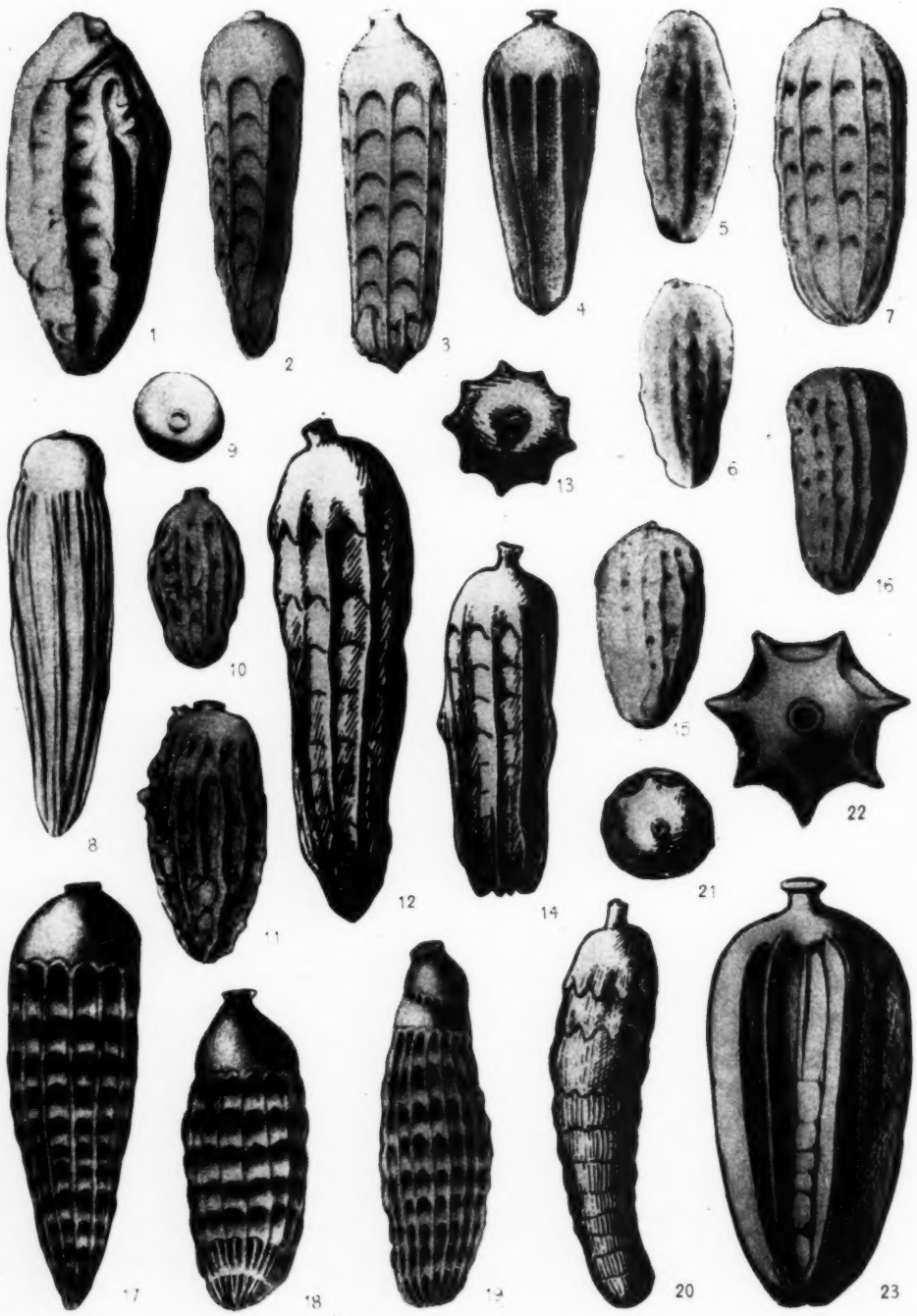

Mathews—Genus Rectuvigerina

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EXPLANATION TO PLATE 83

All figures after the original unless otherwise specified.

FIGS. *1*—*Rectuvigerina collomi* (Cushman), Holotype, ×35. (p. 591)

2, 3—*Rectuvigerina cumingsi* (Galloway and Heminway). *2*, Holotype; *3*, paratype, ×53. (p. 591)

4—*Rectuvigerina spinosa* (Bagg). Original figure, ×40. (p. 597)

5, 6—*Rectuvigerina nuciformis* (Kleinpell). *5*, Holotype; *6*, paratype, ×21. (p. 594)

7—*Rectuvigerina transversa* (Cushman). Holotype, ×35. (p. 598)

8, 9—*Rectuvigerina tenua* (Cushman and Kleinpell). Holotype, side and apertural views, ×25. (p. 597)

10, 11—*Rectuvigerina cubensis* (Cushman and Bermudez). *10*, Paratype; *11*, holotype, ×28. (p. 591)

12–14—*Rectuvigerina senni* (Cushman and Renz). *12, 13*, Holotype, side and apertural views; *14*, paratype, ×60. (p. 596)

15—*Rectuvigerina kleinpelli* (Cushman). Holotype, ×35. (p. 592)

16—*Rectuvigerina reedi* (Cushman). Holotype, ×35. (p. 596)

17–19—*Rectuvigerina branneri* (Bagg). *17*, Original figure; *18, 19*, hypotypes, ×23. (p. 590)

20, 21—*Rectuvigerina kugleri* (Cushman and Renz). Holotype, side and apertural views, ×45. (p. 593)

22, 23—*Rectuvigerina lamellata* (Cushman). Holotype, apertural and side views, ×60. (p. 593)

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EARLY ORDOVICIAN GRAPTOLITES FROM BIG CANYON, OKLAHOMA

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ABSTRACT—Graptolites, and some other hydrozoan-like fossils, occur in the southeast edge of the old Crusher quarry at Big Canyon, Oklahoma in a thick bed of argillaceous limestone thought to be the lower part of the West Spring Creek, the uppermost formation of the Arbuckle group. They include a *Dictyonema*, five forms of extensiform *Didymograptus* and a *Tetragraptus*. This is the first *Tetragraptus* to be found in Oklahoma, and only a few extensiform species of *Didymograptus* are known from a much higher horizon in the Stringtown shale of the Upper Ordovician. The graptolites are described in this paper and the other hydrozoan-like fossils will be described later.

THE very sparse distribution of graptolites in the old Crusher quarry at Big Canyon, Oklahoma has made the task to collect them slow and difficult. The writer makes grateful acknowledgement for assistance in the field to J. O. Beach, Henry Phillips and the manager of the quarry, H. C. Manning, and for the contribution of specimens by Ray Six and F. H. McGuigan.

The graptolites occur on the upthrown side of a thrust fault which seems to have a throw of over 700 feet, bringing this graptolite zone approximately to the same level as the *Didymograptus protobifidus* zone in the north face of the quarry on the other side of the fault.

The *Didymograptus protobifidus* zone on U. S. Highway 77 is 808 feet below the top of the West Spring Creek formation near its base. William Ham has found fragments of graptolites much like some found at the southeast edge of Crusher quarry 770 feet below the *Didymograptus protobifidus* zone. If this is the same zone a throw of over 700 feet along the fault in the Crusher quarry is indicated.

A table showing the distribution and stratigraphic sucession of the pendent graptolites of Arkansas, Oklahoma and Texas has been published by the writer (1944). The extensiform forms of *Didymograptus* have not been found elsewhere in Oklahoma in the lower West Spring Creek formation, and only a few have been collected from a much higher zone in the Stringtown shale.

Class GRAPTOLITHINA Bronn 1846,
emend Lapworth 1875
Order DENDROIDEA Nicholson 1872
Genus DICTYONEMA Hall 1851
DICTYONEMA MANNINGI Decker n. sp.
Figure 16

This is the first *Dictyonema* to be found in the West Spring Creek formation, although members of this genus occur about 3000 feet lower in the Arbuckle group near the top of the McKenzie Hill formation on the Chapman ranch east of U. S. Highway 77 in the Arbuckle Mountains, and in the quarry at Quarry Hill about 80 rods east of the Fort Sill railway station at the east end of the Wichita Mountains.

The specimen illustrated in figure 16 doubtless represents only part of a colony. However, its distinctive characteristics show sufficiently well for description as a species.

The colony has a length of 18.5 mm. and a width of 6 mm. The dissepiments are thin and not closely spaced, giving the colony an open appearance. The meshes are relatively large, varying in length from 4 to 6 mm., and in width from 0.5 to 1 mm. The branches are narrow, 0.25 to 0.5 mm. as a rule, though at places they exceed the latter figure. Thecae are numerous, occurring about 32 in 10 mm., and most of them form an angle of about 45° with the edges of the branches. They average 0.25 mm. in width and 0.5 mm. in length.

Remarks.—This new species has not been found elsewhere. It occurs with *Didymo-*

graptus nitidus and several other extensiform species of *Didymograptus* and *Didymograptus* transients, and with *Tetragraptus postlethwaitii*. This would seem to place it in subzone (b) of the *Didymograptus extensus* zone of Elles (1933, p. 101).

Holotype.—No. B 2320.

Order GRAPTOLOIDEA Lapworth 1875
Genus DIDYMOGRAPTUS McCoy 1851
DIDYMOGRAPTUS NITIDUS (Hall) 1857
Figure 8

This species is common in the Deepkill formation of New York and Ruedemann (1905) listed 12 references and described it as follows:

Primary disk small (diameter about 3 mm.) subcircular, tenuously chitinous, with a central node from which the short, thin nema proceeds. Sicula broad and short (about 1.3 mm. long) branches diverging in their proximal parts under angles varying between 100° and 180° to a distance of 4 to 5 mm., then assuming a horizontal direction; widening gradually to a maximal width of 2.4 mm. (average but 1.6 mm.) attaining each a maximal length of 124 mm. Thecae closely arranged (11 to 13 in 10 mm.) slightly curved, inclined to the axis at an angle of about 40°; three times as long as wide, in contact for two thirds or less in the proximal and for three fourths of their length in the mature portion of the branch. Apertural margin slightly concave, normal on the axis of the thecae (forming an angle of 130° with the axis of the branch).

The specimen illustrated in figure 8 represents only a small part of a colony with about one-sixth of the normal length in one branch and only a few mm. in the other. However, the broad sicula is shown, also the normal increase in width distally, the characteristic overlap of the thecae, and the normal inclination of the thecae.

Remarks.—This *Didymograptus* and the others illustrated represent the first extensiform *Didymograptus* discovered in a formation of the Arbuckle group, though the pendent types are represented by a large member of species.

Didymograptus nitidus occurs in the Lower Ordovician of eastern New York and in Quebec, Canada; in the Skiddaw slates of Great Britain, and in the Lower Ordovician of Australia and New Zealand.

Holotype.—No. B 2321.

DIDYMOGRAPTUS SPARSUS
MAJOR Decker n. var.
Figures 1, 1a, 7, 7a

The specimens illustrated have characteristics nearest to *Didymograptus sparsus* which Hopkinson (1875) described as follows:

Branches linear, elongate, nearly as wide at their origin as any part of their length, diverging from each other at a primary angle of about 240° which by their curving soon becomes 180°; sicula large, obtusely pointed; hydrothecae 15 or 16 to the inch, inclined to the axis at an angle of about 45°, twice as long as wide, and free for half their length; apertural angle about 90°, margin truncate. The maximum width of the branches is one-tenth of an inch; the greatest length observed 3 inches.

Elles and Woods (1901–1918, p. 17) more recent description is as follows:

Stipes 5–7 cm. in length; fairly wide at the origin, and increasing gradually to a maximum of 3 mm.; diverging from a large sicula at a primary angle of 120°, but straightening at once and running horizontally. Thecae 7 in 10 mm., inclined at about 45°, twice as long as wide, free one half their length. The stipes measure 1.6 mm. in width at their origin and gradually widen up to a maximum of 3 mm. They are straight except in the region of the sicula, and have been known to extend for 7.5 cm. on either side of it.

The two incomplete stipes of the variety *major* are respectively 75 and 56 mm. long making the total colonies over 150 and 112 mm. long. This variety differs from the typical form of the species in being 0.5 mm. wider, with greater overlap of nearly three fourths instead of one half, and with the thecae still more sparse, being 6 instead of 7 in 10 mm. In width and the amount of overlap, the variety approaches more nearly to *Didymograptus hirundo* which however has 3 more (9 to 10) thecae in 10 mm. If a complete specimen of the Oklahoma form were available, it might be sufficiently distinctive to be considered a new species.

Remarks.—The significance of the association of this graptolite with the hydrozoan-like forms is not known. The latter are much more openly branched than *Callograptus* or *Dendrograptus* which are common in the lower extensiform *Didymograptus* zones in Great Britain. Also there *D. sparsus* is associated with *D. extensus* and *D. pennatulus*, the former having about one half its width

and the latter more than twice its width. In Oklahoma, the variety is associated with *D. nitidus*, *D. extenus-nitidus* transient, *D. nicholsoni planus* and *Tetragraptus postlithwaitii* as well as *Dictyonema manningi*. *D. sparsus* has not been found elsewhere in North America, nor in Norway, Sweden, Australia, or New Zealand.

Cotypes.—B 2322 and B 2323, University of Oklahoma.

Didymograptus nicholsoni planus
Elles and Wood
Figures 9, 10, 15

Elles and Wood (1901–1918, pp. 28, 29) gave four references and described the species and variety as follows:

> Stipes from 2.5 to 5 cm. in length, uniformly slender, never exceeding 1 mm. in width, diverging from the sicula at angles of 110°–130°. Thecae 10 in 10 mm., four to five times as long as wide, in contact a small fraction of their length, inclined at 25°–30°. Apertural margin normal, straight.
>
> In addition to the typical form of D. nicholsoni there also occurs a variety differing from the type in general shape, and in the lower inclination of the thecae, though agreeing with it in all other essential particulars. The stipes run horizontally, except in the neighborhood of the sicula, where they exhibit marked convex curvature. The inclination of the thecae seems never to be as high as 25°, but always exceeds 20°.

The specimens illustrated by figures 9, 10, 15 are only small parts of colonies from the sicular region. They seem to be more like this variety from the Upper Skiddaw slates of Great Britain than any other form.

Hypotypes are nos. B 2324, B 2325 and B 2326 University of Oklahoma.

Didymograptus extensus-nitidus
transient
Figures 2, 2a, 6, 6a

The specimens illustrated in these figures are transients between *Didymograptus extensus* and *D. nitidus*. The first shows a rather broad sicula 1.5 mm. long with parts of both stipes preserved, each about 25 mm. long. The stipes depart only slightly from the horizontal, and they exhibit broad open curves from sicula to distal ends. The second specimen has a sicula and one stipe 56.25 mm. long. Stipes are narrow proximally and increase gradually to a width of 2.25 mm. Thecae occur 9–11 in 10 mm. In *D. extensus* they are 9–10 mm. and in *D. nitidus* 12–13 in 10 mm. Thecae vary in length from 1 to 2½ mm. and in width from .5 to .75 mm. and overlap from ¼ to ½ their length. Edges of apertures are curved and about normal to the direction of their longer axes.

Remarks.—In Great Britain the *Didymograptus extensus-nitidus* transients occur abundantly in the second subzone above the main *Didymograptus extensus* zone and below the third subzone in which *Didymograptus protobifidas* appears. It is significant that this same succession seems to occur in Oklahoma.

Hypotypes.—B 2327 and B 2328, University of Oklahoma.

Didymograptus sp.
Figure 13

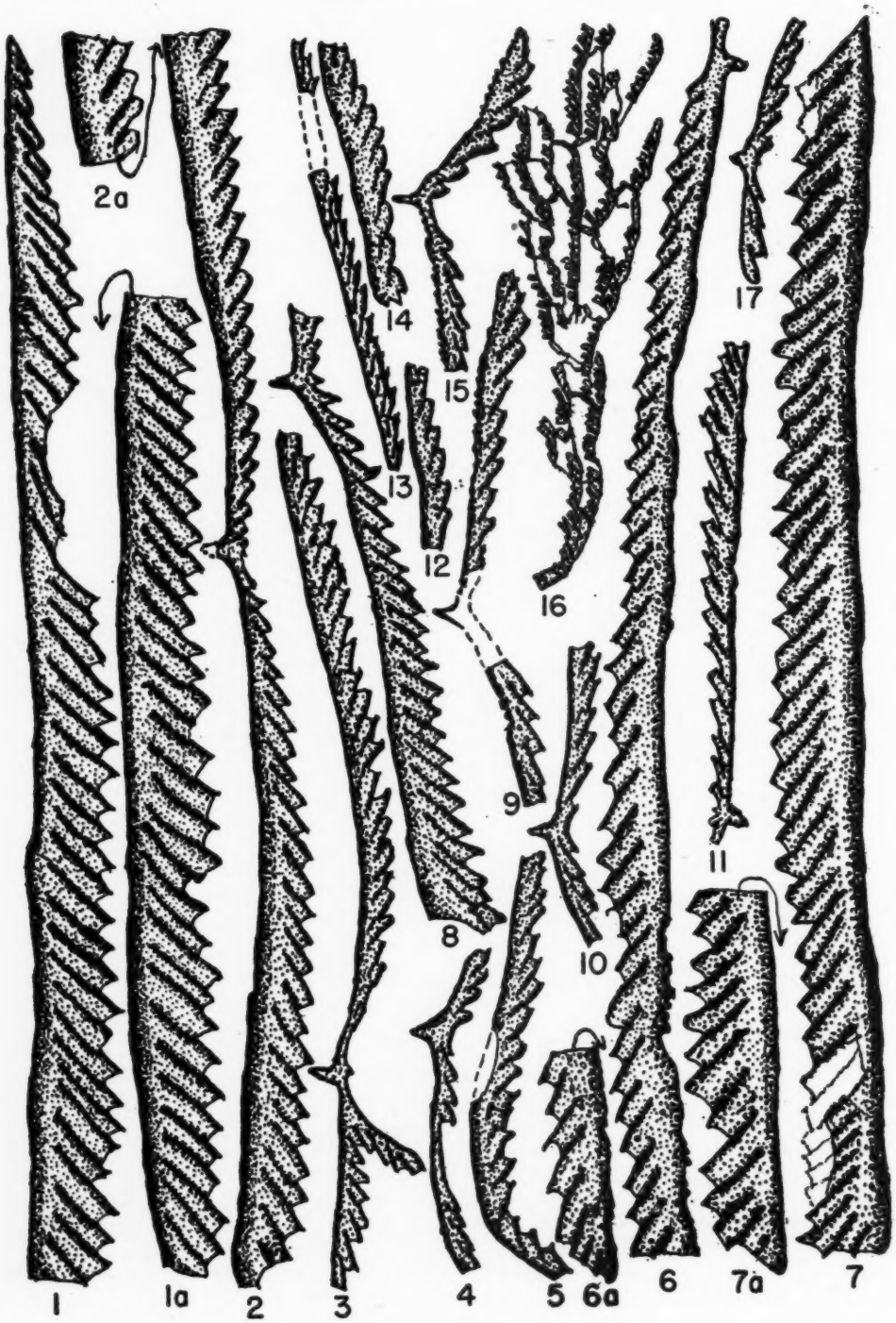
This narrow fragment of *Didymograptus* has a length of 16 mm. and a width of .9 mm. The inclination of the thecae is about 15° and they occur 12 to 13 in 10 mm. This form approaches most nearly to *Didymograptus simulans* Elles and Wood (1901–1918, p. 30) from the Skiddaw slates, but the latter is wider, has more thecae in 10 mm. and has twice as large an angle of inclination.

Specimen.—B 2329, University of Oklahoma.

Genus Tetragraptus Salter 1863
Tetragraptus postlethwaitii Elles
Figures 3, 4, 5, 11, 12, 14, 17

The original description by Elles (1898) is as follows:

> This species belongs to what may be called the *fruticosus* type of *Tetragrapti* Rhabdosome pendent: all the stipes directed vertically or obliquely downwards, narrowest at their origin, but widening somewhat rapidly to a maximum width of 1/16 inch (1.5 mm.). Thecae, long narrow tubes of uniform width, numbering between twenty-eight and thirty to an inch (11 to 12 in 10 mm.); inclined at about 30° with very slight concave curvature and in contact for the greater part of their length. Apertures nearly straight, making an angle of about 130° with the general direction of the stipe.
>
> The species is large and the stipes often attain considerable length; in one specimen a length of 3½ inches (88.7 mm.) has been measured, but the width remains constant at 1/16 inch (1.58 mm.) throughout the whole length.



FIGURES 1–17

Remarks.—The illustrated specimens all have about the width, angle of slope, and number of thecae in 10 mm. as *T. postlethwaitii* and those in figures 3, 4 and 5 show the downward turn of some of the stipes characteristic of that species. The specimen illustrated in figure 3, has two of its stipes nearly horizontal but they do not bend back enough to approach the form of *T. reclinatus* which is much wider and has many more thecae in 10 mm.

The specimen shown in figure 3 has parts of only three stipes, while *Tetragraptus* characteristically has four, and the other specimens are only smaller fragments of colonies. The specimen illustrated in figure 5 shows well the downward bend of the proximal ends of the stipe characteristic of *T. postlethwaitii*. These Oklahoma specimens resemble most closely those illustrated by Benson and Keble (1935) from New Zealand. Specimens are rare in Great Britain and all are from the Skiddaw slates.

Hypotypes.—B 2330–B 2336, University of Oklahoma.

The graptolites in this Oklahoma quarry seem to indicate clearly that the zone in which they occur is equivalent to the lower part of the Deepkill formation of eastern New York and southern Canada, the Lower Ordovician Skiddaw slates of Great Britain, and the Lower Ordovician of Norway, Sweden, Australia and New Zealand.

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EXPLANATION OF FIGURES 1–17

Magnification of all figures is ×4. Drawings by the writer were made with a Parkes-Lapworth graptolite microscope under a camera lucida. The numbered types of the forms illustrated and described in this paper are in the Museum of Invertebrate Paleontology, University of Oklahoma.

FIGS. *1, 1a; 7, 7a—Didymograptus sparsus major* Decker, n. var. Parts of two large stipes. (p. 608)

2, 2a; 6, 6a—Didymograptus extensus-nitidus transient. Both stipes of an almost complete colony, and a single longer stipe with sicula present. (p. 609)

3, 4, 5, 11, 12, 14, 17—Tetragraptus postlethwaitii Elles. One specimen has one complete stipe and parts of two others with fourth one missing. Other specimens are only small fragments of colonies. (p. 609)

8—Didymograptus nitidus (Hall). A large part of one stipe and small part of the other with sicula well preserved. (p. 608)

9, 10, 15—Didymograptus nicholsoni planus Elles and Wood. Proximal parts of three colonies with siculae present. (p. 609)

13—Didymograptus sp. A small fragment of a very narrow colony. (p. 609)

16—Dictyonema manningi Decker n. sp. About one-half of a dendroid colony. (p. 607)

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JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 612–615, PL. 84, NOVEMBER 1945

DEVONIAN CONODONTS FROM NORTHWESTERN MONTANA

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ABSTRACT—Thirteen species of conodonts from an unnamed black shale exposed in Flathead County, Montana, are recognized. From their known occurrences in the black shales of central and eastern United States it is concluded that the shale is of Senecan (Upper Devonian) age. No new species are described.

THE MATERIAL furnishing the conodonts described in this paper was collected by L. L. Sloss of the Montana Bureau of Mines and Geology and Wilson M. Laird of the U. S. Geological Survey. It was obtained from a black shale 30 to 40 feet above the base of the Devonian in the Glenn Creek-White Ridge member of the "Jefferson" of Deiss (1933), but the Devonian of northwestern Montana is not the lithologic or time equivalent of type Jefferson, as recognized by Deiss in later reports (Deiss, 1943). The locality is South Fork trail, one mile south of Mid Creek, SE. ¼ sec. 4, T. 23 N., R. 14 W., Flathead Range, Flathead County, Montana. Devonian stratigraphy of the area is discussed by Sloss and Laird (1945) and requires no further elaboration here.

The previously known occurrences of the species recognized in the Montana samples show a preponderance of forms of Senecan age from the lower New Albany shale of Indiana and the Rhinestreet shale of New York. The presence of three upper New Albany species is not important since two of these also occur in lower zones. The presence of three known from the Grassy Creek shale of Missouri, considered Devonian by Branson and Mehl (1934, p. 179), is in line with the age indicated by other species of the fauna. The one exception, *Hindeodella grandis* Huddle, comes from the upper New Albany shale in Indiana above a calcareous gray shale zone carrying an invertebrate fauna probably similar in age to the Bedford of Ohio and the Hamburg of Illinois (G. A. Cooper, et al., 1942, p. 1774). Therefore the New Albany above this zone should be classed as Mississippian (Kinderhook), the age of the Hamburg as recognized by the Illinois Geological Survey.

Acknowledgement is made to Dr. Sloss for permission to describe the fauna and for the description of the collecting locality.

EXPLANATION OF PLATE 84
(All magnifications ×30)

FIGS. *1—Bryantodus concavus* Huddle. (p. 613)
2—Bryantodus nitidus Ulrich and Bassler. (p. 613)
3—Bryantodus sp. (p. 613)
4, 5—Bryantodus plenus Huddle. (p. 613)
6—Euprioniodina debilis Huddle. (p. 613)
7, 9—Hindeodella aculeata Huddle. (p. 613)
8—Hindeodella rotunda Hibbard (p. 614)
10—Hindeodella grandis Huddle. (p. 614)
11—Hindeodella gracilis Huddle. (p. 614)
12—Hindeodella prioniodon Huddle. (p. 614)
13, 14—Metaprioniodus biangulatus Huddle. (p. 614)
15—Polygnathus cf. *P. rugosa* Huddle. (p. 614)
16—Spathognathodus cf. *S. amplus* Branson and Mehl. (p. 614)
17—Polygnathus triangulatus Branson and Mehl. (p. 614)

Cooper—Montana Conodonts

Genus BRYANTODUS Ulrich and Bassler, 1926

BRYANTODUS CONCAVUS Huddle

Plate 84, figure 1

Bryantodus concavus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 71, pl. 2, figs. 15–17. Lower New Albany shale, Indiana.

Although there is slight variation between Huddle's holotype and paratypes in the number of denticles and the curvature of the bar, this form agrees very closely with the published figures.

The specimens figured, a cast and fragment of the midportion, are slightly smaller than the holotype, but possess the characteristic wide, flat bar surmounted by long conical denticles of extremely variable length and diameter. The cusp is little larger than the largest denticles.

Genus EUPRIONIODINA Ulrich and Bassler, 1926

EUPRIONIODINA DEBILIS Huddle

Plate 84, figure 6

Euprioniodina debilis Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 53, pl. 11, fig 6. Lower New Albany shale, Indiana.

The specimens are identical with Huddle's holotype in such features as the narrow bar, sharply inclined cusp, denticulated projection and the thin, sharp-edged, tapered denticles.

PREVIOUSLY KNOWN DISTRIBUTION OF CONODONTS FROM MONTANA

	New Albany (Indiana)			Rhinestreet (New York)	Grassy Creek (Missouri)
	Lower	Middle	Upper		
Bryantodus concavus Huddle	x				
Bryantodus nitidus Ulrich and Bassler				x	
Bryantodus plenus Huddle		x			
Euprioniodina debilis Huddle	x				
Hindeodella aculeata Huddle		x	x		
Hindeodella gracilis Huddle	x				
Hindeodella grandis Huddle			x		
Hindeodella prioniodon Huddle	x				
Hindeodella rotunda Hibbard				x	
Metaprioniodus biangulatus Huddle			x		x
Polygnathus cf. *P. rugosa* Huddle	x				
Polygnathus triangulatus Branson and Mehl					x
Spathognathodus cf. *S. ampla* Branson and Mehl					x

BRYANTODUS NITIDUS Ulrich and Bassler

Plate 84, figure 2

Bryantodus nitidus Ulrich and Bassler, 1926, U. S. Nat. Mus. Proc. vol. 68, art. 12, p. 24, pl. 4, figs. 12–14. Rhinestreet shale, New York.

The Montana form has slightly fewer denticles and is slightly larger than the holotype, but the ridged nature of the bar and the "lip" beneath the main cusp are identical with the New York form.

BRYANTODUS sp.

Plate 84, figure 3

A fragmentary cast reminiscent of *B. subplanus* Huddle from the middle New Albany shale, but there is not enough preserved for satisfactory identification.

BRYANTODUS PLENUS Huddle

Plate 84, figures 4, 5

Bryantodus plenus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 71, pl. 2, fig. 21. Middle New Albany shale, Indiana.

Genus HINDEODELLA Ulrich and Bassler, 1926

HINDEODELLA ACULEATA Huddle

Plate 84, figures 7, 9

Hindeodella aculeata Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 40, pl. 4, figs. 19–21; pl. 5, figs. 2, 3. Upper and middle New Albany shale, Indiana.

The slightly curved thin bar with its thin sharp denticles of various lengths arranged alternately, the elongate denticulated projection of the bar in front of the fairly long slender cusp are characteristic of this abundant New Albany species.

HINDEODELLA ROTUNDA Hibbard
Plate 84, figure 8

Hindeodella rotunda Hibbard, 1927, Am. Jour. Sci., 5 ser., vol. 13, p. 206, fig. 4 f. Rhinestreet shale, New York.

This species is characterized by a thin bar with extraordinarily large denticles, especially on the posterior end, where they are directed sharply backward.

HINDEODELLA GRANDIS Huddle
Plate 84, figure 10

Hindeodella grandis Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 41, pl. 4, fig. 22. Upper New Albany shale, Indiana.

The wide, heavy bar, slightly bowed and carrying large denticles, alternating with shorter ones are distinguishing features. The cusp is relatively small and the bar anterior of the cusp is long, wide, and thickly denticulate.

HINDEODELLA GRACILIS Huddle
Plate 84, figure 11

Hindeodella gracilis Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 43, pl. 5, fig. 11. Lower New Albany shale, Indiana.

Bar long and wide, unusually long in front of cusp. Differs from *H. grandis* Huddle in having shorter and more slender denticles with several smaller denticles between as compared with one in the latter species. Cusp rather slender and slightly curved.

HINDEODELLA PRIONIODON Huddle
Plate 84, figure 12

Hindeodella prioniodon Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 39, pl. 4, fig. 16. Lower New Albany shale, Indiana.

Bar rounded, rather thin and uniform carrying relatively thick, rounded denticles alternating with two smaller ones; anterior denticles similar to those back of the cusp. Cusp short, wide at base, tapering rapidly.

Genus METAPRIONIODUS Huddle, 1934
METAPRIONIODUS BIANGULATUS Huddle
Plate 84, figure 13, 14

Metaprioniodus biangulatus Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 77, p. 57, pl. 11, figs. 12, 13. Upper New Albany shale, Ind.

Hindeodella tenerrima, Huddle, 1934, idem., p. 46, pl. 5, fig. 18. Upper New Albany shale, Indiana.

Hindeodella acuta Branson and Mehl, 1934, Missouri Univ. Studies, vol. 8, p. 196, pl. 14, figs. 8, 10. Grassy Creek shale, Missouri.

Bar rounded, strongly bowed with wide flat portion in front of cusp. Denticles back of bar long, rounded and inclined backward, alternating with single, very short denticles; those immediately behind cusp short, alternation begins after the fourth denticle. Posterior end curved downward with a short wide, horizontal denticle in line with bar. Cusp fairly long, slender and almost straight.

Genus POLYGNATHUS Hinde, 1879
POLYGNATHUS cf. P. RUGOSA Huddle
Plate 84, figure 15

Polygnathus rugosa Huddle, 1934, Bull. Am. Paleontology, vol. 21, no. 72, p. 98, pl. 8, figs. 12, 13. Lower New Albany shale, Indiana.

This nearly complete cast of the oral surface most closely resembles *P. rugosa* because of the moderately slender plate, slightly curved bar and medial carina, and rows of transverse plications.

POLYGNATHUS TRIANGULATUS
Branson and Mehl
Plate 84, figure 17

Polygnathus triangulatus Branson and Mehl, 1934, Missouri Univ. Studies, vol. 8, p. 247, pl. 21, figs. 16, 20. Grassy Creek shale, Missouri.

The palmate outline; nodular carina, and crenulated margin characterize this species. Only a portion of the bar is preserved.

Genus SPATHOGNATHODUS Branson and Mehl, 1941
SPATHOGNATHODUS cf. S. AMPLUS
Branson and Mehl
Plate 84, figure 16

Spathodus amplus Branson and Mehl, 1934, Missouri Univ. Studies, vol. 8, p. 190, pl. 17, fig. 9. Grassy Creek shale, Missouri.

Mould of a rather wide bar with conspicuous aboral flange. Denticles grading in length and diameter from a maximum on the front end to the smallest on the opposite end.

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JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 616–621, 2 TEXT FIGS., NOVEMBER 1945

GENERA AND SUBGENERA OF THE PELECYPOD FAMILY GLYCYMERIDAE

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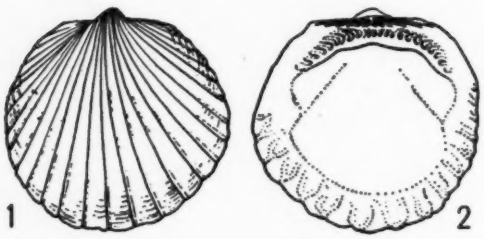
ABSTRACT—The taxonomic validity of every generic and subgeneric name allocated to the pelecypod family Glycymeridae is reviewed, and the genotype of each acceptable genus and subgenus is given. A brief definition of the family is also presented.

THIS family of taxodont pelecypods has been in need of taxonomic study for many years. The following information has been compiled in order to show the superspecific names available for use and to define the limits of the family.

The morphologic characters which define the Glycymeridae are as follows:

Valves closed, equal in size, equilateral; circular, subquadrate, or subtrigonal in outline; isomyarian, integripalliate; beaks



1 2

usually orthogyrate, occasionally opisthogyrate, but rarely prosogyrate, located either at the center or slightly toward the posterior end of the dorsal margin; ligament external but somewhat sunken, amphidetic or prosodetic in position, made up of several chevron-shaped parts, one surrounding the next (duplivincular); hinge plate arched; teeth taxodont, central teeth absent or small, transverse to the hinge when present, side teeth larger, arranged obliquely or parallel to the hinge, largest ones clearly chevron-shaped in appearance; internal ventral border nearly always crenulated, crenulations correspond to the spaces between the radial ribs; radial ornamentation usually present although sometimes secondarily suppressed, concentric ornamentation often present but never strong; shell material porcellanous. An exterior umbonal ridge running from the beak to the posterior ventral border, as in *Trigonarca* and *Peruarca*, rarely occurs in the members of the Glycymeridae. A typical glycymerid is shown in figs. 1 and 2.

The following genera and subgenera are glycymerids, with types whose characters correspond with those enumerated above, and whose names are valid taxonomically. This does not mean that all will be acceptable when careful work on the classification of this family has been completed. Two obvious synonyms are excluded: *Axinaea* Poli, 1791, and *Tuceta* Röding, 1798 (=*Glycymeris* Da Costa, 1778).

Axinactis Mörch, 1861 (p. 203). Genotype (subsequent designation Hertlein and Strong, 1943, p. 153): *Pectunculus inaequalis* G. B. Sowerby, 1833 (p. 196). Recent; Panama, Nicaragua. Figd. Reeve (1843, pl. 4, fig. 16).

Glycymerella Woodring, 1925 (pp. 26, 27). Genotype (original designation): *Pectunculus pennaceus* Lamarck, 1819 (p. 51) =*Arca decussata* Linné, 1758 (p. 694). Recent; West Indies. Figd. Reeve (1843, pl. 5, fig. 24). See Hanley (1855, p. 96) for a discussion of *Arca decussata* and *Pectunculus pennaceus*.

Glycymeris Da Costa, 1778 (pp. 168–170). Genotype (tautonomy): *Glycymeris orbicularis* Da Costa, 1778 (p. 168, table 11, figs. 2.2.) =*Arca glycymeris* Linné, 1758 (p. 695). Recent; Island of Guernsey.

Glycymerita Finlay and Marwick, 1937 (p. 22). Genotype (original designation): *Glycymeris concava* Marshall, 1917 (p. 459, pl. 36, fig. 42). Wangaloan (upper Cretaceous, Danian); Boulder Hill, South Island, New Zealand.

Glycymerula Finlay and Marwick, 1937 (p. 23). Genotype (original designation):

Axinaea modesta Angas, 1879 (p. 418, pl. 25, fig. 4). Recent; 0–40 fathoms, New Zealand.

Grandaxinaea Iredale, 1931 (pp. 202, 203, 231). Genotype (original designation): *Glycymeris magnificens* Iredale, 1929 (pp. 161, 162, pl. 38, figs. 1, 2). Recent; 50–60 fathoms off Montague Island, New South Wales.

Manaia Finlay and Marwick, 1937 (p. 22). Genotype (original designation): *Glycymeris manaiaensis* Marwick, 1923 (pp. 72, 73, pl. 3, fig. 4, pl. 4, fig. 4). Waitotaran (lower Pliocene); Manaia Beach, New Zealand.

Melaxinaea Iredale, 1930 (pp. 73, 74, 87). Genotype (original designation): *Melaxinaea labyrintha* Iredale, 1930 (pp. 73, 74, pl. 9, figs. 1–4). Recent; 9–12 fathoms, Albany Passage, Queensland.

Pectunculopsis Ebert, 1890 (pp. 25–27). Genotype (monotypy): *Pectunculus* (*Pectunculopsis*) *moguntina* Ebert, 1890 (pp. 25–27, fig. p. 25). Middle Oligocene; Weinheim, Germany.

Postligata Gardner, 1916 (p. 543). Genotype (original designation); *Glycymeris* (*Postligata*) *wordeni* Gardner, 1916 (pp. 543, 544, pl. 21, figs. 7–9). Monmouth formation (upper Cretaceous); Friendly, Prince Georges County, Maryland.

Pseudaxinea Monterosato, 1892 (pp. 151, 152). Genotype (original designation): *Pectunculus violacescens* Lamarck, 1819 (p. 52) = *Arca nummaria* Linné, 1758 (p. 695). Recent; Mediterranean Sea. Figd. Reeve (1843, pl. 2, fig. 9). Hanley (1855, p. 100) has examined Linné's specimens of *Arca nummaria* and has found that they are young shells of *Pectunculus violacescens* Lamarck. Despite Hanley's arguments to the contrary, the Linnean name will have to be used as it has priority over *Pectunculus violacescens* of Lamarck.

Tucetilla Iredale, 1939 (pp. 300, 301). Genotype (original designation): *Glycymeris capricornea* Hedley, 1906 (pp. 468, 469, pl. 36, figs. 5, 6). Recent; 17–20 fathoms, Mast Head Reef, Capricorn Group, Queensland.

Tucetona Iredale, 1931 (pp. 202, 203, 231). Genotype (original designation): *Pectunculus flabellatus* Tennison-Woods, 1878 (pp. 61, 62). Recent; Victoria and Tasmania. Figd. Cotton and Godfrey (1938, p. 63, fig. 44).

Tucetopsis Iredale, 1939 (p. 302). Genotype (original designation): *Cardium amboinense* Gmelin, 1790 (p. 3255). Recent; littoral, Amboina. Figd. Reeve, 1843 (pl. 3, figs. 11a, b). *Cardium amboinense* Gmelin is closely related to *Arca pectunculus* Linné, 1758. Distinguishing characters of the two species are given by E. A. Smith (1891, pp. 432, 433).

Veletuceta Iredale, 1931 (pp. 202, 203, 231). Genotype (original designation): *Pectunculus flammeus* Reeve, 1843 (*Pectunculus* species 7. pl. 2, fig. 7). Recent; Twofold Bay, New South Wales.

The following names are rejected from the family Glycymeridae. They include homonyms, synonyms, names referable to other families, names by non-binomial authors, and misspellings. The names *Axinaea*, *Glycymeris*, and *Pectunculus* are easily misspelled as the list will show. The writer does not claim that this list is complete. As many original references were consulted as possible, so that future students of this group will not have to consult these rare papers again. If the original reference was not seen, this is indicated.

Aximea Griffith, 1834 (p. 103). Error for *Axinaea* Poli, 1791.

Axinaea Poli, 1791 (p. 32). Genotype (subsequent designation J. E. Gray, 1847, p. 198, no. 710): *Arca pilosa* Linné, 1767 (p. 1143). Recent; Mediterranean Sea. Figd. Reeve (1843, pl. 3, fig. 13). *Arca pilosa* has often been confused with *A. glycymeris*. Lamy (1911, p. 132) has called *A. pilosa* a variety of *A. glycymeris*. Because the genotypes are so similar, there is no need to consider further the name *Axinaea* of Poli. It can be considered a synonym of *Glycymeris* Da Costa.

Axinaeoderm Poli, 1795 (p. 254). Synonymous with *Axinaea* Poli, 1791. Poli used two names for the same species of mollusk, one for the soft parts, *Axinaea*, and one for the shell, *Axinaeoderma*.

Axinea Rafinesque, 1815 (p. 147). Misspelling of *Axinaea* Poli, 1791. Many authors have used this incorrect spelling. Rafinesque's article was republished by Binney and Tryon, 1864.

Axinia Dautzenberg, 1893 (p. 27). Error for *Axinaea* Poli, 1791.

Axinoderma Herrmannsen, 1846 (p. 100). Error for *Axinaeoderma* Poli, 1795.

Boussacia Cossmann, 1911 (pp. 226, 227). Proposed for *Vasconella* Boussac, 1911, a preoccupied name.

Cnisma Mayer, 1868 (p. 73). Genotype (monotypy): *Pectunculus nuculatus* Lamarck, 1805 (p. 217). Figd. Lamarck (1807, pl. 18, fig. 8a, b), also by Deshayes (1837, pl. 36, figs. 1, 2, 3). Lamarck's and Deshayes' figures and descriptions of *P. nuculatus* prove that this species is not a glycymerid.

Dicranodonta Woods, 1899 (p. 53). Genotype (original designation): *Cucullaea donningtonensis* Keeping, 1883 (p. 152, pl. 8, fig. 9). Lower Greensand, Cretaceous; Upware, England. Figd. also by Woods (1899, pl. 10, figs. 11a–c, 12–14, pl. 11, figs. 1a, b, 2). From the shape, ornamentation, and hinge this species appears to be close to the ancestral stock of the Gly cymeridae. The main difference is in the length and bifurcation of the "side" teeth. See Bernard (1896, pp. 59–75).

Glicymeris Maury, 1924 (p. 411). Misspelling of *Glycymeris* Da Costa, 1778:

Glycemeris Parkinson, 1811 (p. 193). Error for *Glycimeris* Lamarck, 1799.

Glycemeris Fleming, 1828 (p. 410). Error for *Glycimeris* Lamarck, 1799.

Glycimera Blainville, 1824 (p. 353). Not a glycymerid.

Glycimerigenus Renier, 1807 (Tabell. 7). *Glycimerigenus* is the name of the animal, *Glycimeris*, the name of the shell. *Glycimerigenus* Renier is a synonym of *Glycimeris* Lamarck, 1799. See Iredale, (1922, pp. 87–90).

Glycimeris P. Browne, 1789 (p. 411). Browne's names published in 1789 are rejected according to Opinion 89 of the International Rules of Zoological Nomenclature.

Glycimeris Humphrey, 1797 (p. 50). Humphrey's names in the "Museum Calonnianum" can not be accepted according to Opinion 51 of the International Rules of Zoological Nomenclature.

Glycimeris Lamarck, 1799 (p. 83). Genotype (tautonomy): *Mya glycimeris* Born, 1778 (p. 10). A homonym of *Glycymeris* Da Costa. Not a glycymerid.

Glycimeris Schumacher, 1817 (p. 106). Not a glycymerid.

Glycymeris James Sowerby, 1822 (pt. 8). Error for *Glycimeris* Lamarck, 1799.

Limopsis Sasso, 1827 (p. 476). The genotype, by monotypy, *Arca aurita* Brocchi, 1814, is not a member of the family Glycymeridae.

Myopara G. B. Sowerby, 1839 (p. 68). Error for *Myoparo* Lea, 1833.

Myoparo Lea, 1833 (pp. 73, 74). Genotype (monotypy): *Myoparo costatus* Lea, 1833 (p. 74, pl. 2, fig. 51). Claiborne (Eocene); Claiborne, Alabama. Not a glycymerid; hinge characters resemble the Limopsidae.

Nuculella Chenu, 1862 (p. 181). Error for *Nucunella* d'Orbigny, 1850. The incorrect spelling, *Nuculella*, has been used by many authors.

Nucunella d'Orbigny, 1850 (pp. 389, 390). This genus has as its genotype *Pectunculus granulatoides* Galeotti, 1837 (pp. 56, 155) =*Pectunculus nystii* Galeotti, 1837 (p. 184). This species is not a glycymerid.

Pectonculina Paetel, 1875 (p. 154). Misspelling of *Pectunculina* d'Orbigny, 1844.

Pectonculus Latreille, 1804 (p. 115). Original reference not consulted, but according to Schulze et al. (1935, p. 2551), a misspelling of *Pectunculus* Da Costa, 1778.

Pectunculi Huddesford, 1770 (Index 1, p. 6). This name is non-binomial. See Dall (1913, pp. 255, 256).

Pectunculigenus Renier, 1807 (Tabell. 7). See *Glycimerigenus* for discussion. *Pectunculigenus* is a synonym of *Pectunculus* Lamarck, 1799.

Pectunculina d'Orbigny, 1844 (pp. 182, 183). Not a glycymerid, but belongs to the Limopsidae.

Pectunculis Conrad, 1860 (p. 278). Error for *Pectunculus* Lamarck, 1799.

Pectunculites Gesner, 1758 (p. 38). Non-binomial name.

Pectunculites Krüger, 1823 (pp. 458, 459). This, like the rest of the formulae proposed by Krüger, should be rejected. Krüger, Schlotheim, and others added the suffix-*ites* to generic names to indicate fossil species. Krüger's work abounds in vernacular names. See Opinion 72 of the International Rules of Zoological Nomenclature.

Pectunculus Da Costa, 1778 (pp. 183–185). A genus proposed for members of the Veneracea. Not a glycymerid. See Frizzell (1936, p. 49).

Pectunculus Bruguière, 1792 (p. 546). A reprinting of Adanson's name; see Opinion

5 of the International Rules of Zoological Nomenclature.

Pectunculus Humphrey, 1797 (p. 47). Humphrey's names in the "Museum Calonnianum" are not acceptable. See International Rules of Zoological Nomenclature, Opinion 51.

Pectunculus Lamarck, 1799 (p. 87). A homonym of *Pectunculus* Da Costa, 1778.

Pectuncumus Paetel, 1875 (p. 154). According to Paetel *Pectuncumus* Römer is a section of *Cardium* Linné, 1758.

Pectundulus Tate, 1882 (p. 32). Error for *Pectunculus* Lamarck, 1799.

Peruarca Olsson, 1944 (pp. 32, 33). Genotype (original designation): *Peruarca pectunculoides* Olsson, 1944 (p. 33, pl. 3, figs. 6, 7). "*Baculites* zone" (upper Cretaceous); Paita, Peru. This species has an arrangement of the teeth and hinge plate similar to a glycymerid. Other characters, such as an umbonal ridge and shape and position of the teeth, show a close relation to *Trigonarca*.

Petunculus Quoy and Gaimard, 1835 (pp. 466–470). Misspelling of *Pectunculus* Lamarck, 1799.

Protarca Stephenson, 1923 (pp. 103, 104). Genotype (monotypy): *Protarca obliqua* Stephenson, 1923 (pp. 104, 105, pl. 19, figs. 1–3). Snow Hill calcareous member of Black Creek formation (upper part of *Exogyra ponderosa* zone, upper Cretaceous); Snow Hill, Greene County, North Carolina. *Protarca*, like *Peruarca*, shows morphologic similarities to the Glycymeridae on the one hand and *Trigonarca* on the other. The hinge and shape and position of the teeth are like that of a glycymerid. The umbonal ridge and lack of a crenulated ventral margin, as well as the hinge and teeth, show affinities with *Trigonarca*.

Pseudocucullaea Solger, 1903 (pp. 76–83). Genotype (original designation): *Pseudocucullaea lens* Solger, 1903 (p. 77; fig. 1, a, p. 78; figs. 4a, b, c, p. 79). Upper Cretaceous; Kamerun, West Africa. Teeth unlike those of the Glycymeridae, although the remainder of the morphologic characters are similar. Perhaps *Pseudocucullaea* is a synonym of *Lopatinia* Schmidt, 1872. (p. 283)

Stalagmium Conrad, 1833 (p. 39). Genotype (monotypy): *Stalagmium margarataceum* Conrad, 1833 (p. 39). Claiborne (Eocene); Alabama. Possibly referable to the Mytilidae or the Limopsidae.

Trigonarca Conrad, 1863 (p. 289). Genotype (monotypy): *Cucullaea maconensis* Conrad, 1860 (p. 281, pl. 47, fig. 20). Ripley formation (upper Cretaceous); Macon County, Georgia. Figd. also by Stephenson (1923, pl. 14, fig. 10, pl. 15, figs. 1–3, pl. 16, figs. 1, 2). A Cretaceous member of the Arcacea whose hinge, especially position of the teeth, resembles that of a glycymerid. The presence of an umbonal ridge and lack of a crenulated inner ventral margin are morphologic characters unlike those found in the Glycymeridae.

Tuceta Röding, 1798 (pp. 172, 173). Genotype (subsequent designation Dall, 1909, p. 107): *Arca pilosa* Linné, 1767 (p. 1143). Recent; Mediterranean Sea. Like *Axinaea* which has the same genotype, *Tuceta* of Röding may be considered as a synonym of *Glycymeris* Da Costa, 1778. Winckworth (1945, p. 145) has reached the same conclusion.

Vasconella Boussac, 1911 (p. 42). According to Cossmann (1911, pp. 226, 227), this genus belongs to the family Limopsidae, not the Glycymeridae. Original reference not consulted.

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RESTUDY OF SOME MIOCENE SPECIES OF GLYCYMERIS FROM CENTRAL AMERICA AND COLOMBIA

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ABSTRACT—*Glycmeris canalis* Brown and Pilsbry, 1911, from the Gatun formation is redefined and refigured. A new species name, *Glycymeris secticostata*, is proposed for the *Glycymeris canalis* recorded by Olsson, 1922, from the Costa Rica Miocene. Another misidentification is pointed out—*Glycymeris lamyi* Dall reported by Anderson, 1929, from the Miocene of Colombia, is probably identical with *Glycymeris usiacurii* Anderson. *Glycymeris lloydsmithi multicostata* Weisbord, 1929, being preoccupied, is renamed *Glycymeris lloydsmithi striatidentata*.

AT LEAST two well defined groups are discernable among the twenty-odd species of Miocene *Glycymeris* of the Caribbean area which may prove to be worthy of subgeneric or generic rank. A preliminary study of several species centered about *Glycymeris canalis* Brown and Pilsbry was necessary because of many misidentifications and the results are one step toward an improved classification of the family Glycymeridae.

It is a pleasure to acknowledge the assistance given by the following persons: Dr. Henry A. Pilsbry of the Philadelphia Academy of Natural Sciences loaned the holotype of *Glycymeris canalis;* Dr. Axel Olsson gave the writer permission to propose a new name for the specimens from Costa Rica identified as *Glycymeris canalis;* Dr. G. D. Harris of the Paleontological Research Institution loaned the Costa Rica specimens for study; and Dr. Leo G. Hertlein of the California Academy of Sciences and Dr. B. L. Clark of the University of California kindly made available specimens from the Miocene of Colombia and Venezuela.

SYSTEMATIC DESCRIPTIONS

Family GLYCYMERIDAE Stewart, 1930

Genus GLYCYMERIS Da Costa, 1778

Genotype (tautonomy): *Arca glycymeris* Linné, 1758

GLYCYMERIS sensu lato

GLYCYMERIS CANALIS Brown and Pilsbry, 1911

Plate 85, figures 1, 2

Glycymeris canalis Brown and Pilsbry, 1911, Acad. Nat. Sci. Philadelphia Proc., vol. 63, p. 364, pl. 28, fig. 10.

Type specimens.—Holotype no. 1747 is deposited in the Museum of the Academy of Natural Sciences of Philadelphia.

Type locality.—Gatun formation, Miocene; excavation for the locks at Gatun, Panama.

Description.—The following is Brown and Pilsbry's original description of this species:

> The subcircular shell is a little higher than long, solid, equilateral, with nearly straight, contiguous beaks, the ligamental area being extremely narrow and short. Sculpture of 33 strong, rounded ribs separated by linear grooves, and obsoletely marked with rather regular concentric growth-striae. Tooth-row strongly angulated in the middle, with 10 teeth on each side. Inner margin crenulated with about 20 strong "teeth," the upper margins not crenulated.
>
> Length 14.5, alt. 15.1, semidiam. 4.6 mm.
>
> Described from several valves, on which we count 30, 31, 32 and 33 ribs. This species has a close resemblance to *G. pectinata* (Gmel.) of the Antillean fauna, which differs by having wider sulci between the ribs, and by having an area of smaller ribs on the anterior end, while in *canalis* they decrease gradually in size.

To this description further observations must be added: Cardinal margin on either side of beaks strongly arched; chevron-shaped ligamental grooves indistinct; hinge teeth meet regularly at center, middle ones not aborted; crenulations on inner ventral margin pointed, set close together, one crenulation per millimeter. Holotype has 33 strong radial ribs which show no splitting; exterior ventral margin has one rib per millimeter; concentric growth-striae well marked on ribs but not in grooved interspaces.

Comparisons.—Brown and Pilsbry have correctly compared their species with *Glycymeris pectinata. G. canalis* is not closely related to the split ribbed species *G. lamyi*, *G. lamyi tampae*, and *G. usiacurii. G. acuticostata plaisa* Woodring from the Bowden

Miocene of Jamaica has sharper ribs and wider-spaced square crenulations on the inner ventral margin. *G. acuticostata* (Sowerby) from the Tertiary of Santo Domingo is more trigonal in outline and has more sharply crested ribs.

GLYCYMERIS SECTICOSTATA Nicol, n. sp.
Plate 85, figures 3–6

Glycymeris canalis Brown and Pilsbry. Olsson, 1922, Bull. Am. Paleontology, vol. 9, no. 39, pp. 177, 178, pl. 18, figs. 2–7.

Type specimens.—The holotype and five paratypes are deposited in the Paleontological Research Institution Museum at Ithaca, New York.

Type locality.—Gatun formation, Miocene; collection 4, East Grape Point Creek, Costa Rica.

Description.—Olsson's original description is as follows:

> Very abundant locally in the Gatun beds of Costa Rica, are small and medium sized Pectunculids belonging to the group of *G. acuticostata* Sowerby of the Santo Dominican Miocene. They vary somewhat in size, (20 to 32 mm. in height), are usually depressed and with an outline suggestive of the recent East Coast and Upper Miocent *G. pectinata* Gmelin. Typical *acuticostata* does not seem to occur in Costa Rica and I have adopted Brown and Pilsbry name of *canalis*.
>
> The *G. canalis* Brown and Pilsbry from the Canal Zone, and the *trilobicostata* [=*trilobicosta*] Pilsbry and Brown from Colombia, are both based on young shells 15 mm. or less in height. Both forms can be duplicated amongst the Costa Rican shells and are but varieties of the same species.
>
> In its usual and more abundant form, the shell is depressed with numerous (about 26), closely spaced rounded or angled ribs. These ribs are overrun by even, close, concentric threads. They represent the usual *canalis* or its variety *trilobicostata* and average in height about 25 mm. More rarely, the shells are larger and as illustrated by figure 4 and 5 the ribs may become divided into 2 or 3, strong, radial cords. The following measurements will show the usual range in size.

Height 22,	diameter 21,	thickness 5.5
24	23	5.5
32	32	8
29	29	8

Gatun Stage Gatun, C. Z.
Comadre; Banana River; Coll. 4 East Grape Point Creek.
Old Man Sam Creek, C. R.

To Olsson's description the following remarks may be added: Primary ribs knife-like or sharply carinated on top, interspaces linear; on central part of shell primary ribs divide on each side to form three ribs; on both anterior and posterior ends regular division does not take place and there may even be an occasional intercalated rib. There are 16 or 17 denticulations on inner ventral margin of shell, one denticulation to 2.3 mm. There are 24 teeth on hinge of holotype; one paratype has 32; teeth fine, numerous, meeting regularly at center; central teeth not aborted.

The size a specimen attains before the ribs divide varies. One specimen 24 mm in height shows practically no splitting of the ribs, whereas another paratype, only 22 mm., clearly shows a few split ribs. Specimens as much as 28 mm. in height have split ribs well developed. The number of ribs, 26, given by Olsson in his description is for the primary ribs only. Two paratypes have 28 ribs. This number is increased by about three times when the secondary ribs are counted on mature shells.

Comparisons.—This species does not resemble *Glycymeris canalis* in the following respects: It is larger, has angular ribs, which split on attaining a certain size, and the denticulations on the inner ventral margin are square, not pointed at their outer extremities. It differs from *G. trilobicosta* in being larger, the ribs are not brace-shaped nor divided when the specimen attains a height of only 15 mm. Pilsbry and Brown did not mention radial intercalated ribs at the anterior and posterior extremities in *G. trilobicosta*.

G. secticostata most nearly resembles *G. trilobicosta* as reported by Maury from the Brasso, Manzanilla, Machapoorie, and Tamana Miocene of Trinidad but these specimens have the center or main rib more strongly developed.

Glycymeris lamyi Dall from the Tampa Silex beds differs by having fewer and coarser teeth, and the denticulations on the inner ventral border have small depressions in their centers.

The subspecies *G. lamyi tampae* Mansfield has a less convex shell and weaker ribs than *G. secticostata*.

Glycymeris usiacurii and its relatives from the Miocene of Colombia and Venezuela all have flatter and coarser primary ribs.

ADDITIONAL OBSERVATIONS ON MIOCENE GLYCYMERIS

The holotype and topotypes of *Glycymeris usiacurii* Anderson, 1929, (p. 153) and specimens which he identified as *G. lamyi* Dall (from the middle and upper Tuberá group of the Colombian Miocene) were examined at the California Academy of Sciences. None of Anderson's specimens are typical of *G. lamyi* from the Florida Oligocene. The specimens from Colombia so identified have wider and flatter ribs, more numerous and finer teeth, and denticulations on the interior ventral border do not have sunken centers. Careful examination of *G. usiacurii* revealed many similarities between it and the specimens identified by Anderson as *G. lamyi*. Only the holotype of *G. Usiacurii* does not show as marked splitting of the ribs, but it is smaller than specimens referred to *G. lamyi*, and the latter pass through a similar stage of rib formation. The topotypes of *G. usiacurii*, however, show a well developed split ribbed stage. Until more material is collected and better stratigraphic data are obtained all of Anderson's specimens should be referred to *G. usiacurii*.

The appearance of the ribs suggests that *G. usiacurii* is most closely related to *G. loydsmithi "multicostata"* Weisbord from the Colombian Miocene and *G. canalis democraciana* Hodson and Hodson from the Miocene of Venezuela, but the ribs of *G. usiacurii* are more distinctly divided and narrower than those of either of the other species.

Weisbord in 1929 (pp. 10, 11) described from the Miocene of Colombia a new subspecies, *Glycymeris lloydsmithi multicostata*. This subspecific name is a homonym of *Pectunculus multicostatus* Sowerby 1833 (p. 195), now referred to *Glycymeris*, from the Bay of Guayaquil. The writer proposes the new subspecific name *striatidentata*, suggested by the well marked vertical striations on the teeth mentioned by Weisbord in his description.

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JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 625–632, PLS. 85–87, 1 TEXT FIG., NOVEMBER 1945

AMPLEXOID CORALS FROM THE CHESTER OF ILLINOIS AND ARKANSAS[1]

WM. H. EASTON[2]

ABSTRACT—Three new corals are described from the Paint Creek, Golconda, and Fayetteville formations, and one from the Renault is redescribed. The ontogenies of three species are discussed and figured in detail. Possible phylogenetic relationships are considered. Protosepta are inserted in this order: axial septum, left alar septum, right alar septum, left counter-lateral septum, and right counter-lateral septum.

INTRODUCTION

THIS study is offered to bring to light three new species of Chester corals which can be used in correlation and to present detailed discussions of the ontogenetic development of Chester species generally referred to *Amplexus*. A large number of specimens was studied, many of which possessed complete apical portions.

SEPTAL INSERTION AND PHYLOGENY

Two recent papers contain excellent bibliographies of ontogenetic studies of rugose corals. Grove (1934) has presented a detailed objective review of the principal studies of fossil corals and Hill (1935, pp. 505, 506) has published a very concise statement of the septal arrangement among the rugose corals, which is quoted below.

> Insertion of meta-septa takes place at four points,[3] immediaately on each side of the cardinal septum, and on the counter side of each alar septum.
>
> Referring, first to the cyathaxonid type, insertion of meta-septa is always accompanied by insertion of minor septa as follows [fig. 1b]:—[4] On each side of the cardinal [C] and both counter-lateral [CL] septa a new short septum arises. Those [1X] on the counter side of the counter-lateral septa remain short and are minor septa; the others [1] lengthen, and immediately on each side of them a new short septum arises. That on the counter side [2X] remains short and is a minor septum; that on the cardinal side [2] lengthens to become a major septum, and two new short septa are inserted one on each side of this new major septum, the one on the counter side [3X] being a minor septum, and the other [3] growing to become a major septum, and so on.
>
> In a second group [fig. 1a, the zaphrentid type], by far the largest, at first after the insertion of the six proto-septa, only meta-septa arise at the four points of insertion, and minor septa (which in this group are obviously delayed) later appear in rapid succession in all the loculi, after which major and minor septa arise at each point of insertion as in the first group.

It is not yet fully agreed as to whether the rugose corals have four or six primary septa, the counter-lateral septa being called metasepta by some students. Disregarding the philosophical implications, however, it has been demonstrated that the order of insertion of the first six septa is as reviewed by Grove (1934, pp. 119, 120):

> I. A single septum stretches entirely across the calicle, from wall to wall. At a considerably later stage this breaks near the center, the two halves forming the cardinal and counter septa. This first formed septum Carruthers designated as the "axial septum."
>
> II. Two new septa arise, one on either side of the axial septum, at its cardinal end. These remain attached to the wall of the corallum and to the axial septum, but gradually spread outwards, and eventually become the alar septa.
>
> III. A second pair of septa appear at the counter end of the axial septum, and similarly spread outward, but to a much more limited extent than the first pair.

Grove goes on to say that the "disruption of the axial septum completes the formation of six primary septa," but this does not always happen at this stage; indeed, it may not happen until a much later stage, if at all.

All four of the amplexoid corals considered here have the zaphrentid type of septal insertion. The species restricted to the Paint Creek formation differs from the others in having an early mature stage in which the septa of the counter quadrants are dilated and in having short or rudimentary minor

[1] Published by permission of the Chief, Illinois State Geological Survey, Urbana, Illinois.

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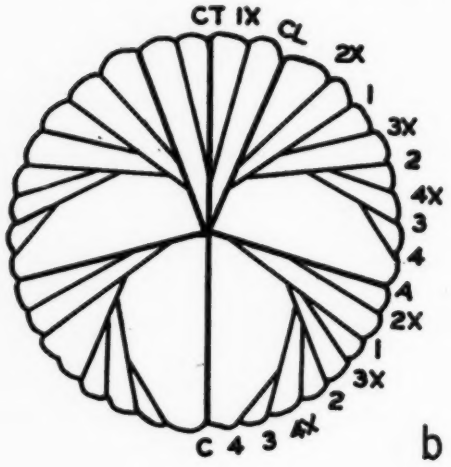
[3] Exceptions are known.

[4] This and subsequent brackets are the writer's.

septa in very late mature stages. This species appears to be related to *Amplexus rockfordensis* Miller and Gurley. The other three species are apparently closely related members of the Hapsiphyllidae. The nature of septal insertion and the presence of cardinal



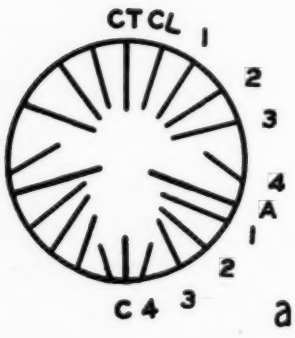


FIG. *1a, b.*—Principal systems of insertion of septa in the rugose corals. *1a*, "zaphrentid" type; *1b*, "cyathaxonid" type; A, alar septum; C, cardinal septem; CL, counter-lateral septum; CT, counter septum; 1–4, major metasepta; 1X–4X, minor metasepta. (Modified from Hill, 1935.)

fossulae and of alar pseudofossulae at some stage in each of these species are strong arguments for assigning such a relationship.

Early septal insertion in these amplexoid corals as found by the writer starts with an aseptate condition, after which the axial septum appears. The left alar is next inserted, followed by the right alar, the left counter-lateral, and the right counter-lateral septa in that order. The first metaseptum is inserted in the left counter quadrant and the second metaseptum is inserted in the right counter quadrant. Axial fusion of the primary septa tends to persist into mature stages. This order of insertion is somewhat at variance with that commonly understood to obtain in that most writers have found the alar septa to be inserted simultaneously as a pair, followed by the counter-lateral septa also as a pair. The writer (Easton 1945, p. 385) found that the right alar system was the first to be inserted after the axial septum in *Kinkaidia trigonalis.*

Contratingent minor septa, which lean toward the counter quadrants and are joined to the next adjacent major septa are well known and aid in rapid orientation of sections, but the writer is not aware that anyone has pointed out the apparent contratingent nature of tabular intersections near the epitheca in those corals in which the peripheral edge of a tabula slopes from the counter position proximally toward the cardinal position. This feature can be used to orientate sections (pl. 87, figs. 12, 13) in which the septa are not capable of differentiation on other grounds.

The writer noticed several abnormalities of septal relationships during this work. The amplexoid trend is apparently increasingly strong as maturity progresses, but some septa in early stages may be withdrawn after insertion. The position of a septum may be clearly established from study of septal grooves, but the actual insertion of the septum may be retarded. Occasionally, one will find in the counter quadrants a metaseptum attached to the alar septum for a time, rather than to the next preceding metaseptum. The rate of septal insertion is subject to wide extremes of variation in a single species, as exemplified by very rapid insertion of septa, followed by very slow insertion. Examples in which one of a pair of quadrants contains more metasepta than the other are common and are usually indicative of contortion or geniculation of the corallite. In the attached apical portion of one species, the alar septa, though presumably tending to be inserted

in normal sequence, are not observable until after a counter-lateral septum appears, their actual presence apparently being indicated, however, by slight internal swelling of the epitheca (pl. 86, fig. 2a). Further study of sections in the same sequence bears out the observation that the arrangement of septa is independent of the effects of attachment, for the plane of attachment cuts across the plan of septal arrangement without their being any adjustment of the center of symmetry.

ACKNOWLEDGMENTS

The writer is indebted to Carey Croneis of Walker Museum, University of Chicago, and R. C. Moore of the University of Kansas, for lending specimens used in this study. Some locality data were furnished by J. Marvin Weller.

SYSTEMATIC DESCRIPTIONS

PHYLUM COELENTERATA
Class ANTHOZOA
Order TETRACORALLA
Family HAPSIPHYLLIDAE
Genus AMPLEXUS of authors

Diagnosis.—Simple, conico-cylindrical, rugose corals with broad generally complete tabulae; septa more or less radial in arrangement, extending to the axis over the upper surfaces of most tabulae, but extending distally from each tabula a progressively shorter distance as the axis is approached; dissepiments and columellar structure absent.

Occurrence.—Silurian to Permian of many parts of the world.

Remarks.—Amplexus (*sensu stricto*) was founded upon *A. coralloides* by Sowerby in 1814, but since that time a wide variety of species has been referred to this genus on the basis of their simple structure. Type material of *A. coralloides* has never been sectioned in early stages, hence, the morphology of the genotype is inadequately known. Paleontologists now seem to be generally agreed that corals of simple structure similar to *A. coralloides* may very well belong to some genus other than *Amplexus*, but ontogentic studies still largely remain to be done before polyphyletic relationships of "*Amplexus*" can be demonstrated satisfactorily.

AMPLEXUS ADNATUS Easton, n. sp.
Plate 85, figure 9; plate 87, figures 1–7

Externals.—Ceratoid to trochoid geniculate corals with apical angle usually about 20°; epitheca with numerous rather fine encircling wrinkles, prominent septal grooves and interseptal ridges which always originate in connection with a pair of adjacent septa; spines commonly extending from one side, especially near apical end, parracidal increase common, with new calyx starting from some eccentric position and with epitheca commonly grown over old calyx. Average length about 20 mm. with range from about 10 to 30 mm.; average diameter about 6 mm., but flared specimens may be 11 mm. in diameter at calyces.

Transverse sections.—Septa not numerous, mostly reaching center, even in late stages. (See "ontogeny" for details.)

Longitudinal section.—Tabulae nearly all complete, with little or no axial sag, relatively abruptly recurved proximally near peripheries.

Occurrence.—Abundant in the Golconda formation in the Vienna quadrangle. Collected by Stuart Weller from his locality W-312, which may be the E½, NW¼, sec. 28, T. 13 S., R. 3 E., near top of the bluff on the high point of land between two creeks 4½ miles south-southeast of Vienna, Illinois; also occurring in the Paint Creek formation.

Material.—Holotype, No. 47248; paratypes and topotypes, not numbered; all in Walker Museum, University of Chicago. Ideotypes, Walker Museum No. 47249, Illinois State Geological Survey No. 3537.

Ontogeny.—The earliest stage observed (pl. 87, fig. 1a) has an axial septum which consists of the fused cardinal septum and counter septum. In the next observed stage (fig. 1b) both alar septa are present, of which the left is the thicker and has migrated farther from the cardinal septum, therefore, it probably was inserted before the right alar. Other stages were not observed before that in which the left cardinal quadrant contains one metaseptum, the right cardinal quadrant none, the left counter quadrant the probable counter-lateral septum, and the right counter quadrant one metaseptum and the counter-lateral septum (fig. 1c). This asymmetrical arrangement presumably is a manifestation of geniculation of the corallite.

Next (fig. 1d) each cardinal quadrant contains one metaseptum and each counter quadrant contains two metasepta. It will be noticed that the metasepta of the left counter quadrant are aberrant in that they lean toward the alar septum and that some of them may not reach the axis (figs. 1c–1f). Traces of tabulae can be observed in the last mentioned stage (fig. 1f), and the alar pseudofossula is developed only on the right side of the coral. The right alar pseudofossula still persists when 14 major septa are present (fig. 2), and each cardinal quadrant has one well developed metaseptum attached to the cardinal septum. The cardinal fossula soon becomes apparent but the alar pseudofossulae are represented only by slightly wider loculi than occur elsewhere; the cardinal quadrants each contain two metasepta and the counter quadrants three or four (fig. 3). When 16 major septa have been inserted (fig. 4), there are three metasepta in each cardinal quadrant and three or four septa in each counter quadrant, but several septa have retreated a short distance from the axis. At full maturity (fig. 5) there are 22 major septa, of which three are in each cardinal quadrant and six in each counter quadrant, thus, the counter quadrants are accelerated by the time maturity is reached. Amplexoid retreat is very poorly shown, inasmuch as those septa which do not reach the axis are either fused near their axial edges, or else lean against a neighboring metaseptum. The amplexoid condition is developed by middle maturity, nevertheless, as shown by a section just below a tabula (fig. 7).

Comparison.—This species can be distinguished externally from the other species of *Amplexus* by the small size of the corallites, their contorted shape, nearly cylindrical mature portions, calical method of increase, occasional development of spines on one side, about twice as many septal grooves as septa, and by the insertion of two adjacent septa as a pair.

Remarks.—Septal notation was verified through study of the septal grooves wherever possible. In this regard, it was observed that although minor septa are nowhere developed, a septal groove usually occurs between major septa, hence there are usually about twice as many septal grooves as septa.

Ontogenetically, this species is characterized by the slow rate of insertion of major septa, by marked acceleration of the counter quadrants in mature stages, and by very poorly developed amplexoid retreat.

Phylogenetic relationships are with the so-called "zaphrentid" types, except that the fossulae are poorly developed and primary septa tend to remain fused axially. *A. adnatus* appears to be closely related to *A. geniculatus.*

Apical portions of most corallites are so contorted and spinose that study of epithecal ornament is unsatisfactory, however, it was noted in some specimens that the cardinal position is on the convex side of the corallite. It is not known how general this may be, for the cardinal position was also observed to be on some other side in a few specimens.

Wherever observed, the corals were attached by spines to a fragment of a fenestellid bryozoan. One coral has two distinct and separate patches of spines and is geniculate in such a manner as to suggested that the animal originally was recumbent along a bryozoan frond and then altered its direction of growth in order to make the corallite vertical, but the bryozoan frond either broke or its position was changed so that the coral was again recumbent and sent out spines.

AMPLEXUS DILATATUS Easton, n. sp.

Plate 85, figure 10; plate 86, figures 4, 5

Caninia n. sp. Weller, 1920, Illinois Geol. Survey, Bull. 41, pp. 170, 173.

Externals.—Curved ceratoid corals; epitheca nearly smooth with encircling wrinkles, relatively faint septal grooves and interseptal ridges, occasionally with sparse spines; calyx rather deep, vertically walled; calical increase observed, with epitheca grown over old calyx. Mature specimens about 3 cm. long; diameter of calyx about 10 mm.

Transverse sections.—Mature section of holotype (pl. 86, fig. 4b) has 27 major septa extending about half the radius, of about equal strength but cardinal and counter septa are slightly longer than other major septa; minor septa short or rudimentary.

In early maturity (fig. 4a) holotype has 19 major septa; cardinal septum short; metasepta of cardinal quadrants pinnately arranged: alar septa almost reach axis; septa

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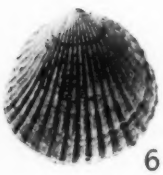
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Nicol—Miocene Glycymeris
Easton—Chester Corals

of counter quadrants somewhat dilated, three grouped in palmate bunches on either side of long counter septum; minor septa rudimentary.

At slightly earlier stage (fig. 5) in a paratype, septa of counter quadrants much dilated; septa of cardinal quadrants thin, sinuous.

Longitudinal section.—Not prepared.

Occurrence.—All specimens are from thin limestone lenses in Paint Creek shale about 10 to 15 feet below the Cypress sandstone, on the south bluffs at Indian Point overlooking the valley of Cache River, in sec. 32, T. 13 S., R. 3 E., Johnson County, Illinois.

Material.—Specimens studied, 3; holotype, no. 47247; figured paratypes, not numbered; all in Walker Museum, University of Chicago, collected by Stuart Weller.

Ontogeny.—Early stages not preserved.

Comparison.—This species differs from the other Chester amplexoid corals in having the septa of the counter quadrants dilated in early maturity, and in having relatively strong development of minor septa.

The species can be identified externally by its curved conical shape, sparse spines, and common occurrence of the cardinal position on the convex side of the corallite.

Remarks.—*A. dilatatus* has typical so-called "zaphrentid" type of septal pattern. It appears to be related to *A. rockfordensis* from the Rockford beds (Kinderhook) of Indiana.

AMPLEXUS EXPANSUS Easton, n. sp.
Plate 85, figure 8; plate 86, figures 1–3

Externals.—Ceratoid, slightly curved with apical angle about 30°; epitheca generally with fine encircling striae distally but with septal grooves and interseptal ridges proximally, wrinkled throughout; apical end recurved, commonly much less flared than rest of coral, with very fine encircling striae, flattened on one side (cardinal side wherever observed) where apparently attached to foreign body; sections reveal rather deep calyx (about ⅓ length of corallite) vertically walled and lined with septa. Specimens range in length from about 1.5 cm. to 3.5 cm.; diameter of calyx about 12 mm.; early attached portion from 2 to 4 mm. long.

Transverse sections.—Septa become amplexoid rapidly, beginning their retreat at stage of about 17 septa. (See "ontogeny" for details.)

Longitudinal section.—Tubulae nearly all complete, about 8 in 1 cm., recurved proximally near peripheries and with proximal sag in axial region.

Occurrence.—Fayetteville shale, 6 miles east and 1.5 miles north of Vinita, Oklahoma. Collected by Maurice Wallace and Arthur Bowsher.

Material.—Specimens studied, 37; holotype, figured paratypes, unfigured paratypes, and topotypes, not numbered; all in the collections of the University of Kansas.

Ontogeny.—Most of the septa are inserted

EXPLANATION OF PLATE 85

FIGS. *1, 2*—*Glycymeris canalis* Brown and Pilsbry. Holotype no. 1747, Academy of Natural Sciences of Philadelphia. *1*, Right valve, exterior, ×2. *2*, Right valve, same specimen, interior, ×2. Gatun formation, Miocene; Gatun, Panama. (p. 622)

3–6—*Glycymeris secticostata* Nicol, n. sp. *3*, Holotype, right valve, exterior, ×1; Gatun formation, Miocene, Costa Rica. Second paratype right valve, juvenile, exterior, ×1. *4*, Right valve, same as specimen *6*, interior, ×1. *5*, First paratype, right valve, exterior, ×1. Holotype and second paratype from Collection 4, East Grape Point Creek; first paratype from Banana River. Holotype and five paratypes in Paleontological Research Institution, Ithaca, New York. (p. 623)

FIGS. *7*—*Amplexus geniculatus* Worthen. Side view; holotype; XI; Illinois State Geological Survey (Worthen collection) No. 2566a. (p. 630)

8—*Amplexus expansus* Easton, n. sp. Side view; paratype; XI; University of Kansas. (p. 629)

9—*Amplexus adnatus* Easton, n. sp. Side view; holotype; XI; Walker Museum No. 47248. (p. 627)

10—*Amplexus dilatatus* Easton, n. sp. Side view; holotype; XI; Walker Museum No. 47247. (p. 628)

in the very early unflared portion of the corallites (pl. 86, figs. 1a–1h, 2a–2h). Although not actually observed, the earliest stage presumably is aseptate. The earliest observed stage (fig. 1a) has an axial septum extending across the center of the thecarium consisting of the fused cardinal septum and counter septum. In every observed instance, the cardinal septum is more or less normal to the plane of attachment of the corallite. At the next stage (fig. 2a) the left counter-lateral septum is inserted but this apparently unorthodox sequence is caused by the alar septa being crowded against the epitheca parallel with the plane of attachment and only faintly observable in sections; they are first clearly seen at the next stage (fig. 2b) which has an axial septum, counter-lateral septa, and the fully developed alar septa starting to become separate from the epitheca. The coral grows larger (fig. 2c) and eventually adds a metaseptum in the left counter quadrant (fig. 2d) and then another in the right counter quadrant (fig. 2e). This corresponds to about the same stage shown in figure 1b, but the latter specimen is aberrant in having the center of symmetry offset toward the counter position. There may be a tendency after this stage for the septa to retreat from the axis (figs. 1c–1f), but even though this occurs, the septa may reverse the trend (figs. 1g–1i) before beginning their final retreat (fig. 1j) and attaining maturity (fig. 2i). After two metasepta have been inserted along with the alar septa, a metaseptum appears in the left cardinal quadrant (fig. 1c) and then another in the right cardinal quadrant (fig. 2f). When each counter quadrant has four septa, and the cardinal quadrants each have two metasepta, the final septal retreat (fig. 1i) starts by axial thinning of septa. Alar septa and the counter septum are longer than other major septa and the cardinal septum soon becomes quite short (fig. 1j), but in maturity (fig. 2i) the alar septa and the cardinal septum are shorter than the others and the counter septum is the same length as the neighboring metasepta.

Comparison.—This species is readily identified externally by the flaring corallites and by the brephic stage in which the epitheca is equipped with very fine encircling striae and bears the flattened area where it was attached to some foreign object (patterns of costate brachiopod shells were commonly observed). These features serve to distinguish *A. expansus* from other Chester amplexoid corals.

Remarks.—Ontogenetically, this species is characterized by early and rapid retreat of the major septa, by insertion of about half the total number of major septa before notable flaring of the calyx begins, by nearly radial arrangement of septa in late stages, and by nearly uniform thickness of major septa in late stages.

Phylogenetic relationship is with the so-called "zaphrentid" types but the species is clearly of different ancestry than the other Chester "*Amplexus*."

Amplexus geniculatus Worthen

Plate 85, figure 7; plate 87, figures 8–14

Amplexus geniculatus Worthen, 1890, Illinois Geol. Survey, vol. 8, p. 82, pl. 10, figs. 7, 7a.

Externals.—Large simple corals, commonly geniculate near apical end and occasionally contorted in cylindrical portion; calyx rather deep, nearly vertically walled; epitheca occasionally spinose but always with very prominent septal grooves and interseptal ridges; corallites commonly ceratoid to trochoid near apical end, with abrupt change to nearly cylindrical shape, or gradually expanding. Average length about

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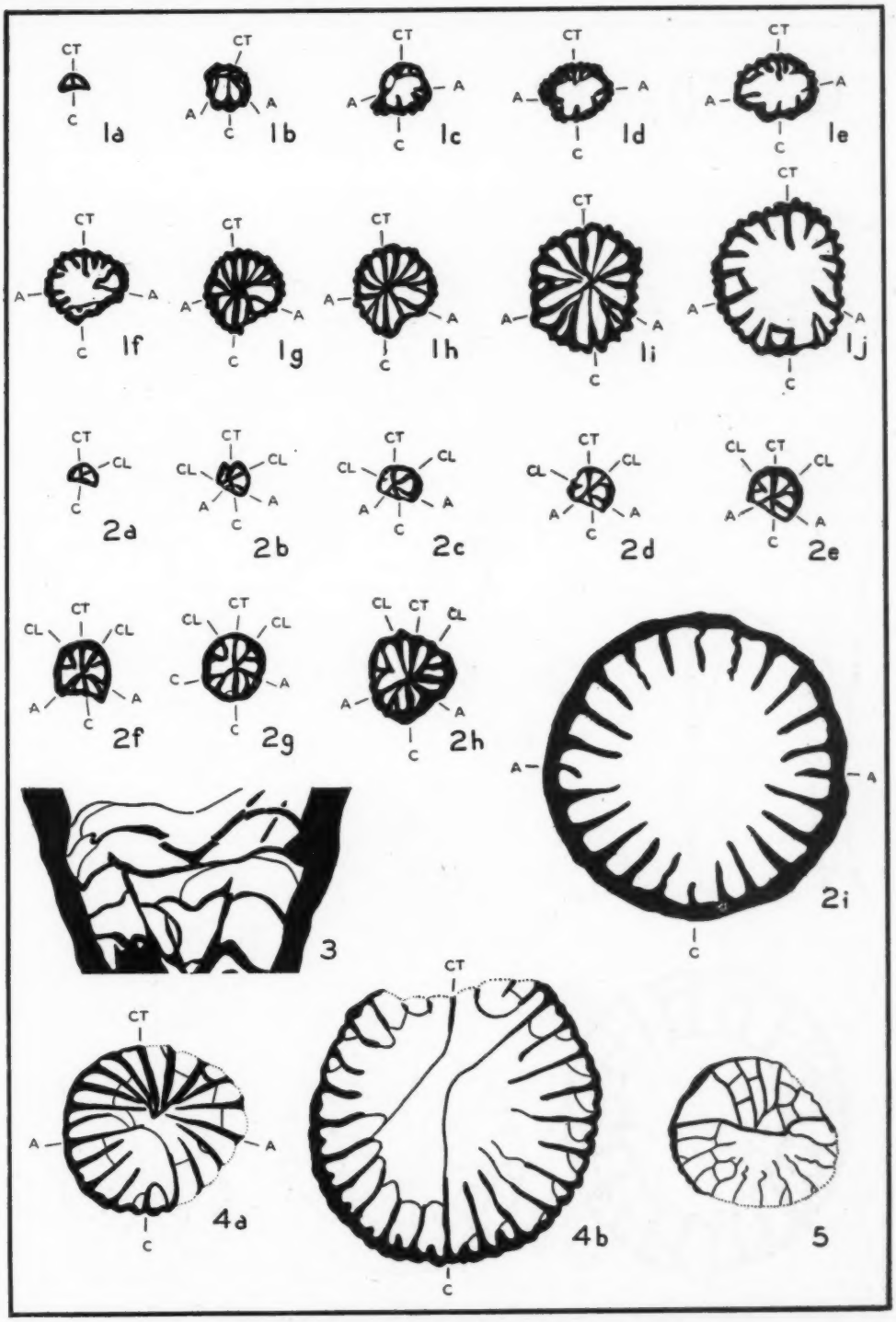
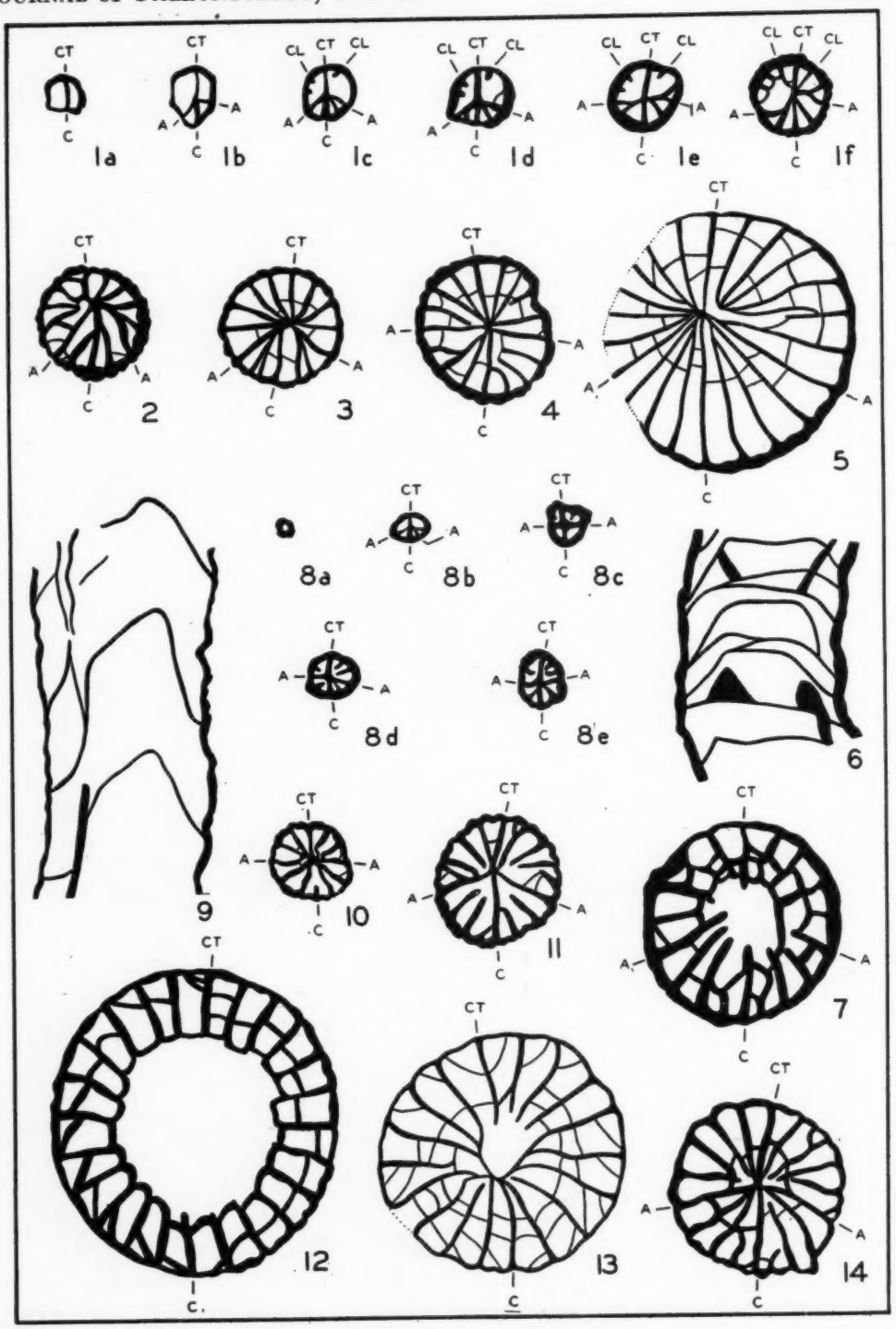
Explanation of Plate 86

Figs. *1–3*—*Amplexus expansus* Easton, n. sp.; paratypes; University of Kansas collections; ×5. *1a–j*—Transverse serial sections; reversed; 1 specimen. *2a–i*—Transverse serial sections; reversed; 1 specimen. *3*—Longitudinal section. (p. 629)

4–5—*Amplexus dilatatus* Easton, n. sp.; Walker Museum collections; ×5. *4a–b*—Transverse sections; holotype; No. 47247. *5*—Transverse section; reversed; paratype. (p. 628)



Easton—Chester Corals



Easton—Chester Corals

4.5 cm.; average diameter at calyx about 9 mm.

Transverse sections.—Septa thin, relatively few in number, generally meet at axis; tabular intersections common, straight. (See "Ontogeny" for details.)

Longitudinal section.—Tabulae about 4 mm. apart, highly arched distally, the peripheral edges sloping proximally from counter to cardinal position.

Occurrence.—The type locality was originally given as "Chester limestone, Pope County, Illinois," but subsequent studies have shown the species to be restricted to the Shetlerville member of the Renault limestone of Lower Chester age.

Material.—Specimens studied, 62; holotype, Illinois State Geological Survey (Worthen collection) No. 2566a; paratype, same collection, No. 2566b; figured plesiotypes, Illinois State Geological Survey No. 3526–3531, 3536, and University of Illinois No. X-1479; unfigured plesiotypes, Illinois State Geological Survey Nos. 3532–3535. The writer has studied Illinois specimens from the grey-green shale cropping out on the east bank of the ravine above the old Bean and McMaster's quarry near Shetlerville; from ¾ mile south of Eichorn; from Melcher Hill in Hardin County; and from the ravine east of Shetlerville.

Ontogeny.—Before any septa are inserted (pl. 87, fig. 8a) there is simply a ring of epitheca. Presumably septa are inserted in an orderly manner as in the other species studied, in which case the axial septum extended across the thecarium, then the left alar, right alar and left counter-lateral septa were inserted (fig. 8b) but these stages have not been observed. The alar septa migrate toward the counter septum until they stand at right angles with the axial septum, by which time the right counter-lateral septum has appeared (fig. 8c). The next observed stage (fig. 8d) shows one metaseptum in each cardinal quadrant and one metaseptum and the counter-lateral septum in the left counter quadrant and the counter-lateral in the right counter quadrant. These relationships persist a short time (through fig. 8e). but in the next section (fig. 10) each quadrant has one metaseptum in addition to a counter-lateral septum, and tabulae occur. Subsequently, acceleration of the counter quadrants occurs and they contain four or five septa while the cardinal quadrants contain two or three metasepta (fig. 11). By this stage most of the metasepta are withdrawn from the axis, although they have shown an impersistent tendency to retreat since an early stage (fig. 8c). Moreover, the epitheca is lined with septal grooves between major septa, but this suggestion of minor septa is probably misleading because the grooves seem to correspond with longitudinal wrinkles inside the thecarium, rather than to actual rudimentary minor septa. Later, rudimentary minor septa are definitely present. At full maturity, the septa are usually about 20 to 24 in number and occur in many different patterns, varying between a radial arrangement in which most septa nearly or quite reach the axis (fig. 14) and the typical amplexoid pattern (fig. 12) in which the septa are withdrawn toward the periphery and do not extend vertically throughout their length between adjacent tabulae. An intermediate pattern (fig. 13) is obtained if the plane of a section passes just below a tabula.

EXPLANATION OF PLATE 87

FIGS. *1, 6, 13*—*Amplexus adnatus* Easton, n. sp.; paratypes; Walker Museum collections; ×5. *1a–f*—Transverse serial sections; reversed; 1 specimen. *2–4*—Transverse sections; reversed; 3 specimens. *5–13*—Transverse sections; 2 specimens. *6*—Longitudinal section. *7*—Transverse section just below a tabula. (p. 627)

8–12, 14—*Amplexus geniculatus* Worthen; plesiotypes; Illinois State Geological Survey collection, except fig. 13; ×5. *8a–e*—Transverse serial sections; reversed; 1 individual; No. 3526. *9*—Longitudinal section in cardinal-counter plane; No. 3527. *10–12*—Transverse section; reversed; 3 specimens; Nos. 3528, 3529, 3530. *13*—Transverse section; No. 3526. *14*—Transverse section, reversed; University of Illinois No. X-1479. (p. 630)

Remarks.—Ontogenetically, this species is characterized by the marked acceleration of the counter quadrants and by the slow insertion of metasepta after very early maturity.

Phylogenetic relationships are clearly with the so-called "zaphrentid" types, and *A. geniculatus* appears to be closely related to *A. adnatus.*

This species is readily identified externally by the large, long, slender corallites which may be geniculate and sparsely spinose and almost always show interseptal ridges and septal grooves.

MANUSCRIPT RECEIVED JUNE 9, 1944.

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JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 633–636, PL. 88, NOVEMBER 1945

SEVERAL UPPER CAMBRIAN FOSSILS FROM THE UPPER MISSISSIPPI VALLEY AND A GIANT GRAPTOLITE FROM THE LOWER MIDDLE ORDOVICIAN OF NEWFOUNDLAND

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ABSTRACT—Unusual specimens of two trilobites and a cryptozoan from the Upper Cambrian of Wisconsin and a Middle Ordovician graptolite from Newfoundland are described and illustrated.

DIKELOCEPHALUS OWENI Ulrich and Resser

Plate 88, figure 3

Dikelocephalus oweni. Ulrich and Resser, 1930, Milwaukee Public Mus., Bull., vol. 12, no. 1, pp. 32–35, pls. 5, 6, 7 and Pl. 8, figs. 1–3.

THE specimens described below seem to be larger than any previously recorded from the Upper Cambrian of the Upper Mississippi Valley. Ulrich and Resser may have had some specimens as large, but, as no scales were given for most of their illustrations, one is left in doubt as to the dimensions of their specimens. Our specimens were found by a W.P.A. workman in the Lodi shale at an excavation for road material near Galesville on the Mississippi River in western Wisconsin. They were brought to the attention of the writer through the courtesy of the Editor of the Galesville Republican who also arranged their purchase from the workman. They are now in the collections of the Department of Geology of the University of Wisconsin.

The specimens consist of two slabs of which one is the counterpart of the other. Impressions of two pygidia and two cranidia are preserved. Fragments of the test are present on some parts of the impressions and it seems likely that considerably more shell matter may have been present when the specimens were collected. There is an excellent impression of a very large pygidium and a much poorer impression of a considerably smaller one. One of the two cranidia is upside down. The excellent preservation and the large size are considered justification for description. All specimens are referred to *D. oweni* but the characters do not seem to be identical with those described by Ulrich and Resser. However, our specimens are nearer to this species than any other described by these authors.

The large pygidium has a total length of 94 mm. and the greatest width is 159 mm. The ratio of length to width is 1.7. The ratio of the specimen of *D. oweni* figured by Ulrich and Resser is 131 to 75 or about 1.7. The length of the axial lobe of the pygidium is 58 mm. with width at the front of 36 mm. and width at the posterior end just before the abrupt rounding begins of 24 mm. The segmented part of the axial lobe is 37 mm. long. The axial lobe ends abruptly with gentle and uniform rounding. The width of the pygidium from tip to tip of the posterior spines is 135 mm., width from inner bases of the spines is 121 mm. A straight line drawn from tip to tip of the spines cuts across the pygidium 3 mm. from the middle point of the posterior margin showing that this margin is gently curved. A straight line connecting the inner bases of the posterior spines cuts across the pygidium 8 mm. from the middle point of the posterior margin. The pleural segments are unlike in shapes and dimensions. The anterior margin of the pygidium is gently and uniformly curved and this curve extends to the outer bases of the posterior spines without much change. Distance from the tip of a spine to the anterior end of the groove separating the axial from the pleural lobes is 98 mm. The smaller pygidium is not so well preserved, the spines seem to be more acute, the axial lobe has a much less rounded and sharper termination, and the posterior margin of the pygidium is curved to a shorter radius. These differences are assumed to be due to the fact that a much younger individual is represented.

The anterior brim of the cephalon has about the same width as the distance between the eyes, the width across the brim on the larger of the two specimens being 54 mm. and the distance between the eyes 55 mm. In the smaller of the two cranidia the same dimensions are 27 and 28 mm. respectively. The general shape of the glabella is quadrate with a gently rounded anterior margin which is almost part of a circle. The total length of the cephalon of the larger specimen is 51 mm. and the total length of the glabella is 34 mm. This glabella is 32 mm. wide at the eyes, the smaller is 17 mm. at the same place. The anterior glabellar furrow is shallow on the margin, becomes obsolete on the axis and is directed slightly posteriorly. The second glabellar furrow is deep and well defined and has a gentle backward curve. The third glabellar or occipital furrow is also sharply defined and is almost straight from side to side, but there is a slight curve posteriorly. The furrow on the fixed cheek back of the eyes is offset posteriorly from the third glabellar furrow, trends backward at first and then forward as it approaches the lateral margin. The width of the fixed cheek at the middle of the eye is 11 mm. on the larger specimen and 6 mm. on the smaller one.

The axial lobe of the pygidium has the gradually rounded extremity present in *D. oweni* and the specimen figured by Ulrich and Resser, pl. 7, fig. 1, has about the same ratio of length to width. The pleural segments of the pygidium have about the same variations in shapes and dimensions, and the posterior spines in Ulrich and Resser's specimen seem to be similar. The end of the axial lobe in the Ulrich and Resser illustration appears to have a different shape from the specimen here described and the posterior margin of this pygidium is not shown to be slightly wavy as is the case with our specimen. Similar waviness is shown by a specimen of *D. raaschi* from which our specimen differs in the shape of the axial lobe and in less acute pygidial spines. The curvature of the posterior margins is similar. The pygidium of our specimen is much larger than any figured by Ulrich and Resser but these dimensions are approached by *D. oweni*. The waviness of the posterior margin is probably due to conditions of preservation.

The writer is doubtful respecting the validity of several of the eighteen species described by Ulrich and Resser from the Lodi shale of the Upper Mississippi Valley. This is a member of the Trempealeau formation and usually is 10 to 20 feet thick but reaches a thickness of 30 feet in some places. The Lodi shale is a siltstone and represents a silty bottom environment. Its variation in thickness evidently depended on the competencies of the transporting currents in the sea in which deposition took place. Where current competency carried sands to places where silt had previously been deposited, this resulted in less thickness to the silt deposits. Eighteen species of a single genus is a large number to occur in such a thin lithologic unit and the writer knows no other member of comparable thickness in the geologic column characterized by so many species of one genus. Many of the Ulrich and Resser species were founded on few specimens and no entire ones were available. The characters used to differentiate their several species seem to be of doubtful value and before most of these species were erected, extents of variations should have been determined. Moreover, few of the specimens are more than impressions with shells almost or entirely wanting.

EXPLANATION OF PLATE 88

FIG. *1*—Characteristic form of *Cryptozoa* in the St. Lawrence dolomitic limestone. The specimen is about average dimension and the specimen figured is 16.5 cm. high, and 16 cm. wide at the base, (× ca. ¼). Many show that the sediments accumulated around and over them and then settled. This Cryptozoan is not always present, but, if present, it tends to be very abundant. (p. 635)

2—*Tellerins crassimarginata* (Whitfield), ×½. (p. 635)

3—*Dikellocephalus oweni* Ulrich and Resser, ×½. (p. 633)

4—*Didymograptus* sp. This specimen is 35.5 inches long as shown by the yard stick at the side. The two branches join at A and the terminal end of each branch is not present. (p. 636)

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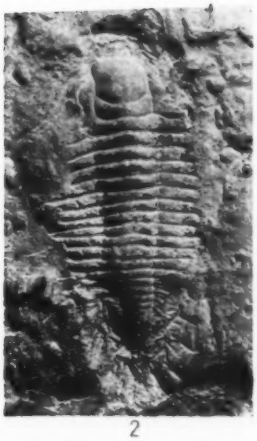

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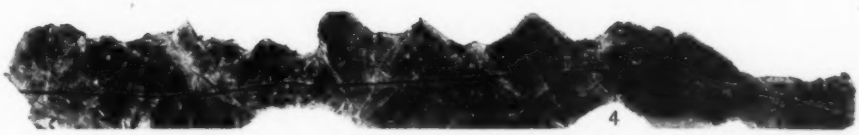

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Twenhofel—Cambrian and
Ordovician Fossils

TELLERINA CRASSIMARGINATA (Whitfield)
Plate 88, figure 2

Dikelocephalus crassimarginata Whitfield, 1882, Geology of Wisconsin, vol. 4, p. 344, pl. 27, fig. 14.

Tellerina crassimarginata Ulrich, 1933, Milwaukee Public Mus. Bull., vol. 12, no. 2, pp. 244–249, pl. 41, figs. 1–9, pl. 42, fig.

This specimen is one of the very rare nearly entire trilobites known from the Upper Cambrian strata of the upper Mississippi Valley. It was found by Mr. Carl Albers of Madison, Wisconsin, in the Lodi shale member of the Trempealeau formation near Mazomanie, Wisconsin, and it was presented by him to the Department of Geology of the University of Wisconsin. The specimen is not perfect in that the front part of the cephalon, the free cheeks, and the posterior margin of the pygidium are not present. It retains no shell matter.

The length from the approximate anterior margin of the glabella to the end of the axial lobe of the pygidium is 71 mm., the probable width across the thorax is 35 mm. and the width of the glabella at the middle of the palpebral lobes is 14 mm. The sides and front of the glabella are well defined, the sides converge from the rear to about the position of the first glabellar furrow and then diverge anteriorly. The length of the glabella from its anterior margin to the rear of the occipital segment is 18 mm. There are three segments to the glabella of which the anterior is the largest. The first glabellar furrow is regularly curved posteriorly and well defined. The second furrow first curves posteriorly to about half way to the top of the glabella and then curves anteriorly to cross the axis. It has the shape of a bow. Thus the glabellar segment in front of this furrow is narrower on the axis than on the sides. This is also the case for the occipital segment. The width of the cranidium across the eyes is 20 mm.

The thorax has 12 segments which are smooth on the axis and seem to be smooth also on the pleura, but as no shell is present the nature of the original surface is uncertain. The thorax is 37 mm. long and the width about mid-length is 32 mm. The axial lobe of the thorax narrows from a width of 14 mm. in front to about 12 mm. in back.

There are six segments in the pygidium. It has a width on the anterior margin of about 30 mm. and a probable length of over 25 mm. The length of the axial lobe is 17 mm. A straight line connecting the anterolateral margins of the pygidium crosses the axial lobe between the second and third segments of the pygidium, showing that the anterior margin is gently curved. The posterior segment of the axial lobe of the pygidium is half-cone-shaped and the length is nearly one third the total length of the axial lobe. The axis tapers gradually. Lateral edges of both thorax and pygidium are not well shown.

CRYPTOZOA IN THE ST. LAWRENCE MEMBER OF THE TREMPEALEAU FORMATION
Plate 88, figure 1

The Trempealeau formation of the Upper Cambrian in the upper Mississippi Valley has been divided into four members which are, from the base upward, the St. Lawrence dolomitic limestone, the Lodi shale, the Jordan sandstone, and the Madison sandstone. The writer sees no reason for recognition of the Madison sandstone as a separate member. He considers it only the locally better cemented upper part of the Jordan member which because of the cementation has permitted its use as a low grade building stone. It contains few fossils and one may search for hours without finding any and the few that have been found belong to the same genera present in other parts of the Trempealeau formation.

In the area about Madison, Wisconsin, the St. Lawrence limestone was named the Mendota limestone by Irving in 1875, but the name St. Lawrence, from a railroad station in the Minnesota valley, had been given to this limestone the year before by N. H. Winchell. Ulrich introduced the term Black Earth for a dolomitic limestone present in the same stratigraphic position as the St. Lawrence and exposed on the west end of Lake Mendota (only 8 miles west of the type outcrop of the Mendota limestone) and in the valley of Black Earth Creek to the west. He also placed the Mendota limestone in a position above the Jordan and below the Madison sandstone although no one had ever found that limestone in this position in any outcrop or subsurface section. Moreover, at its type locality the Mendota limestone is overlain by the Lodi shale which

also overlies the Black Earth limestone only a few miles to the west. In all exposures the limestones are underlain by the Franconia glauconitic sandstone. It has never been clear what induced Ulrich to make this assignment, but it seems to have been done on the basis of fossils which are always few and mostly different in different exposures. Ulrich also postulated an unconformity of great magnitude between the Jordan and Madison members and he asserted that in the development of this unconformity the Mendota limestone had been removed.

The St. Lawrence (Mendota, Black Earth) limestone locally contains many dome-shaped *Cryptozoa*. Some are cones rather than domes. These are entirely dolomitized and exhibit essentially no structure other than laminations parallel to the surfaces of the domes. The Oneota dolomitic limestone which overlies the Trempealeau formation also contains many *Cryptozoa*, but these are broadly dome-shaped and are easily distinguished from those in the St. Lawrence limestone. It is not considered wise to designate the *Cryptozoa* in the St. Lawrence by a specific name, but it is thought desirable to note the differences in shape of the *Cryptozoa* in the two limestones so closely associated.

A GIANT GRAPTOLITE FROM THE LOWER MIDDLE ORDOVICIAN OF NEWFOUNDLAND

Plate 88, figure 4

During the field season of 1939 in Newfoundland a large *Didymograptus* was found on a bed of siltstone in Zone 5 of the Schuchert and Dunbar section of the lower Middle Ordovician. This zone is exposed on the east side of the north end of Port au Port Bay, western Newfoundland, one to two miles north of a place known as the Gravels. The specimen found and collected is so large that it is considered worthy of notice. Schuchert and Dunbar had earlier noted the occurrence of a large species of *Didymograptus*.

This large specimen was found on a bed of much jointed siltstone about two inches thick enclosed in dark-colored shales containing other graptolites. Collection of the specimen on a single slab was out of the question because of the much jointed character of the rock. Collection was done by numbering the separate joint blocks in proper order. These were then removed and later reassembled and mounted in plaster of paris. The specimen was evidently longer as erosion had removed parts of the siltstone into which the ends of the specimen had extended.

The specimen is 35.5 inches long (89 cm.) with both ends missing, of which 5¾ inches (13 cm.) represent one branch and 30⅛ inches (76 cm.) the other. The two branches diverge at an angle of about 180 degrees. The specimen originally was longer, but one may only conjecture as to original lengths of the branches. The flattened rhabdosome is about 2.75 mm. wide and the width is about the same from one end to the other. Slight differences in width from place to place may have been caused by differences of flattening in the sediment. There are about eight thecae to a centimeter.

Associated with this giant form of *Didymograptus* is another species, which seems related to *D. forciformis*, and an oboloid brachiopod. Schuchert and Dunbar list *Phyllograptus*, *Climacograptus*, and *Tetragraptus* cf. *quadribrachiatus* from their zone 5.

Most of these species were noted by Professor Schuchert and the writer in 1910 when they studied the same exposures, but no specimen as large as the one described was seen. This specimen and fragments of the same species are in the collections of the Department of Geology of the University of Wisconsin.

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REVISION OF FOSSIL PTEROPODA FROM SOUTHERN ANATOLIA, SYRIA AND PALESTINE

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ABSTRACT—Pteropods from southern Anatolia and northern Syria, previously considered to be Upper Cretaceous, prove to be of Miocene age. Eleven species are described, one of them new, all closely related to the Pteropoda of the southern European Middle Miocene. In Palestine pteropods occur in the Middle Eocene.

INTRODUCTION

AN ACCOUNT on the pteropods from the Upper Cretaceous of north Syria (*5*, pp. 593–602, pl. 22) was published in 1889 by M. Blanckenhorn, the well known student of geology of the Middle East. This paper was of particular interest as Pteropoda were not known to occur in strata older than the Eocene. The so-called "Pteropoda" of the Paleozoic and Mesozoic are very different from this group and probably do not belong to it (*23*, p. 399).

Blanckenhorn discussed the age of four pteropod-bearing outcrops (see fig. 1) situated in remote localities of northern Syria. All of them were believed to be of the

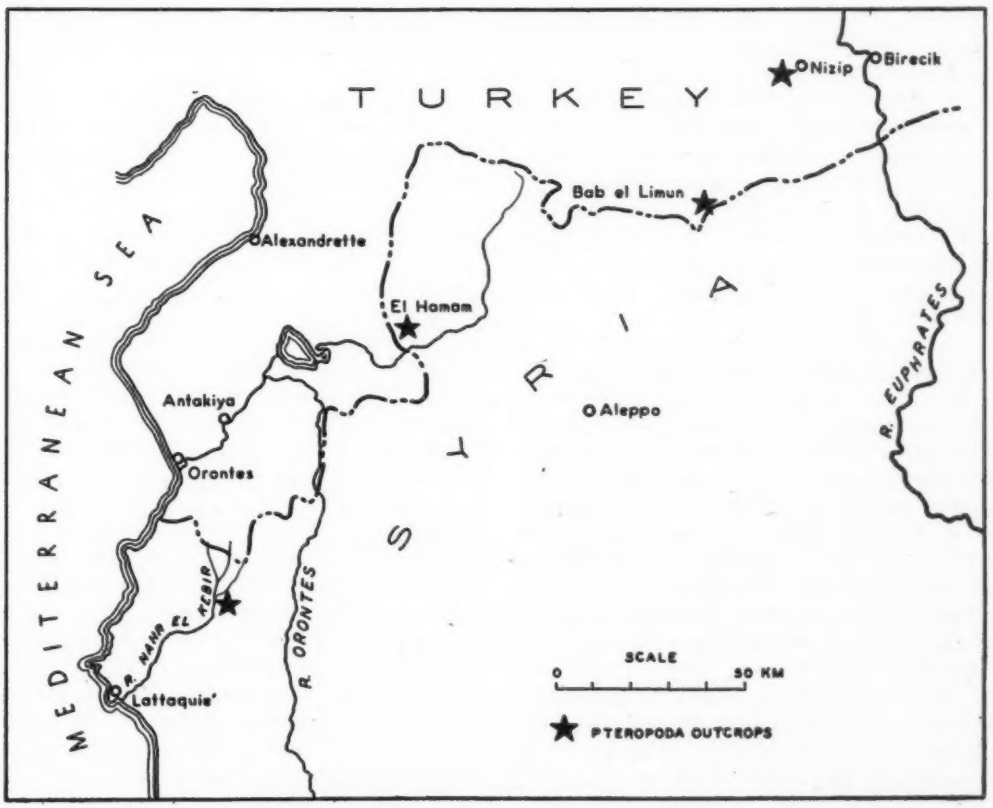

FIG. 1—Sketch-map showing locations of Pteropoda outcrops in southern Anatolia and northern Syria.

same age, certainly Upper Cretaceous and probably Senonian.

The first outcrop is situated in the valley of Nahr el Kebir, between the village Safkoun and Khan Ahmed Hammadeh, northeast of Latakia (Ladikiyeh or Lattaquié), on the road to Jisr el Shuggar. There, a greyish-yellow marly shale includes numerous casts of *Vaginella* (p. 594). In order to explain the stratigraphic position of this outcrop, the author described a section beginning in the middle of the Nusairieh Mountains between the rivers El-Kebir (Nahr el Kebir) and the Orontes. He stated that obscure Pteropoda occur there in a zone supposed to be situated ("müsste meines Dafürhaltens") above an *Inoceramus* limestone and below the "Nummulites" beds. In reality no Pteropoda are present at this position and this reported occurrence is very misleading.

The second pteropod outcrop bears the name of Bab el Limun, midway between Aleppo and Biredjik (Birecik), west of the river Sadjar-Su. Here were found:

Balantium flabelliforme Blanckenhorn
Balantium amphoroides Blanckenhorn
Vaginella labiata Blanckenhorn
Vaginella rotundata Blanckenhorn
Styliola sp.

Two other Pteropoda possibly belonging to the genera *Gomopleura* (=*Cavolinia*) and *Spirialis* (=*Limacina*) were also mentioned.

The rock is of the same character as in the Safkoun-area, a clear marly chalk.

In a third outcrop, west of Nizip (Nisib) on the way to Deirbistan, west of the Euphrates (Turkish territory) white chalk contained specimens of *Balantium flabelliforme* Blanckenhorn and *Tentaculites cretaceum* Blanckenhorn together with a *Terebratula nicaisei* Coquand, a brachiopod known from the Cenomanian of North Africa. Also Pteropoda, possibly belonging to the genera *Gomopleura* and *Spirialis* were recognized here.

The fourth and last locality at El Hamam is on the east shore of the Ak Deniz or Lake Antiochia (erroneously stated on p. 597 to be west of the lake), where a yellowish-white marl is dotted by remains of *Creseis* sp.

A systematic description of the pteropods was given. All of them represented new species and as such they were naturally without much stratigraphic value.

A year later, in 1890, Blanckenhorn's paper on the Cretaceous of Syria (*6*), appeared in which he dealt again with the pteropods (pp. 56, 59, 60, 118–120, pl. 9). There he repeated the statements given in the former paper with one change only: the pteropods of the outcrop near Safkoun (a), quoted before under the general name of "*Vaginellas*," were differentiated as two species—*Vaginella labiata* and *V. rotundata*.

The third publication in which Pteropoda were mentioned was Blanckenhorn's general account on his investigations in northern Syria which appeared in 1891. This was accompanied by a diary which is important in locating the Pteropoda-outcrops (*7*, pp. 45, 53, 56, 65).

In a volume on the regional geology of Syria, Arabia and Mesopotamia, which appeared in 1914, the same author refered the pteropods of Syria to Senonian horizons (*8*, p. 24).

The last time Blanckenhorn dealt with the Pteropods was in his monograph on Cretaceous bivalves from Syria and Palestine (1934). Here he renamed *Vaginella labiata* from near Safkoun *V. senonica* (*9*, p. 275). It is not clear whether the formerly quoted *V. rotundata* was included in the new species as well.

On the basis of these works the occurrence of Pteropoda in the Upper Cretaceous of Syria has been recorded in some standard paleontological textbooks, like the German work of K. Zittel revised by Broili (*26*, p. 475), the English edition of this book by Eastman (*26a*, pp. 570–571) and the latest Russian revised edition (*26b*, pp. 698–699) where "Syria" was erroneously printed "Siberia." The newest, "Index Fossils of North America" by H. W. Shimer and R. R. Schrock, p. 517 also records the occurrence of *Vaginella* in the Cretaceous of Syria. Some modern paleontologists also have been misled, as for instance, R. Rutsch in his paper on Miocene pteropods from Trinidad (*20*). Only P. Oppenheim seemed to express some doubt as to such an early appearance of Pteropoda, pointing out in his publication on the Oligocene formation of Niemtschitz in Czechoslovakian Moravia (1922, p. 82),

that *Tentaculites cretaceus* Blanckenhorn from the Senonian of northern Syria is identical with the Middle Oligocene "*Balantium maximum* Ludwig" from Hesse in Germany and from Moravia.

In 1936 the author of the present paper published a note on the pteropods of Syria and Palestine (*1*), in which he suggested that the Pteropoda of Syria are not of Senonian but of Eocene age. Recent geological investigations in northern Syria and in Tauric Anatolia have given sufficient evidence to assign an even younger age to this fauna. It is difficult to locate the Pteropoda-outcrops of Blanckenhorn from his descriptions alone, but with the aid of his diary and the map in his account of 1891 (*7*) and by comparing them with the recent maps of Dubertret (*10*) and of Stchepinsky (*22*) it was possible to reach quite clear conclusions. The first outcrop near Safkoun is situated—according to the map of Dubertret—in a Miocene area and this was also confirmed by him in a letter (dated Feb. 24, 1942). The outcrop of Bab el Limun, on the way from Aleppo to Birecik is easy to find as a basalt flow south of it is indicated on both the maps of Blanckenhorn and Dubertret; accordingly this locality is Miocene or, more exactly, a Helvetian facies of Vindobonian (Middle Miocene) age. The location of the outcrop west of Nizip is somewhat doubtful because the map of Stchepinsky indicates several formations in close proximity; nevertheless Miocene age seems most probable. It is also important that the rock specimens from Bab el Limun and from Nizip are nearly identical in character. The last outcrop at El Hamam in the Antiochia region, is indicated on Dubertret's map as Miocene.

Similar conclusions were reached through paleontological examination of the Pteropoda, which are of quite distinct Miocene character. Furthermore the study has revealed a close relationship between the Syrian and North Mediterranean and Pannonian Neogene. Thus the revision of Syrian pteropods is more than of local interest.

In connection with this subject it is not superfluous to add some general remarks on the ecology of Pteropoda. Their occurrence may well illustrate the facial conditions of the corresponding epochs. The Pteropoda are typical planctonic-pelagic animals, like *Globigerina*, etc. The former opinion that they belong to deep sea sediments has been abandoned. It is quite true that their shells constitute an important part of sediments on sea bottoms from 200 m. to nearly 3000 m. depth, but living pteropods are met almost exclusively in the upper 100–400 m. This life zone is controlled by the diurnal convective currents: at the beginning of the day the Pteropoda descend some 200–400 m. but at sunset they appear in crowds on the surface of the sea.

This mechanism of movements is evidently partly responsible for the distribution of Pteropoda in the seas, for they cannot exist in too shallow water where the convective movement can be of only small amplitude and does not protect them against the destructive influence of strong light.

Theoretically the pteropods, as pelagic and widespread organisms occurring through all the oceans, may be of great help to the stratigrapher but practically their use is much restricted. The shells consist of aragonite and therefore they are generally not preserved at a depth greater than 3000 m. This fact also accounts for their disappearance or for their great rarity or at best their preservation as moulds in formations older than the Neogene. Even in younger formations their preservation is rarely good.

REVISION AND RECTIFICATION OF SYRIAN PTEROPODA

All the specimens collected and mentioned by Blanckenhorn are now included in the collections of the Geological Department of the Hebrew University in Jerusalem where they have been examined. The fossils are preserved in generally soft, more or less marly limestone as internal moulds or impressions and therefore their specific determinations cannot be exact. There are some distinctions, according to localities, in the petrographical character of the limestone. The rock near Safkoun, in the valley of Nahr el Kebir, is light-grey, microforaminiferal, soft, and granular. That at Bab el Limun, between Aleppo and Birecik is yellowish-white, very fine-grained, *Globigerina-Orbulina* limestone, stained with

limonite commonly occurring in tiny rods which possibly occupy borings of *Arenicola*-like organisms. Rock specimens from west of Nizip, in the valley of the Upper Euphrates are identical. The grey marly limestone with characteristic conchoidal fractures from Hammam Ak Deniz in the depression of Lake Antiochia is rich in big Globigerinas (*triloba* Reuss) and Orbulinas.

The results of our revision are as follows:

SYSTEMATIC DESCRIPTION

Order PTEROPODA

Suborder THECOSOMATA

Stirps EUTHECOSOMATA

Family CAVOLINIDAE

Genus STYLIOLA (Lesueur) Blainville 1827

STYLIOLA aff. S. SUBULA (Quoy and Gaimard)

Figure 2

1889. *Creseis* sp., aff. *C. spinifera* Rang and *C.*

a) Specimens from near Safkoun, in the valley of Nahr el Kebir, northeast of Latakia (Syria). Reg No. 11784.

The material consists of three rock specimens containing numerous internal moulds or impressions of pteropods. Altogether there are some 25 complete or fragmental individuals. We have distinguished here:

Blanckenhorn's determinations	Corrections and additions
1. *Vaginella* sp. (e.p.), 1889 = *V. labiata* 1890 = *V. senonica* 1934	*Herse senonica* (Blanckenhorn) and *H.s. inflata* Avnimelech
2. *Vaginella* sp. (e.p.), 1889 = *V. rotundata* bl., 1890	2a. *Vaginella calandrellii* (Michelotti)
	2b. *V. ? testudinaria* (Michelotti)
	3. *Clio ? carinata* Audenino

b) Specimens from Bab el Limun, between Aleppo and Birecik. These are registered under five numbers as follows:

	Blanckenhorn's determinations	Corrections and additions
No. 2096	1. *Balantium amphoroides*	1. *Vaginella calandrellii* (Michelotti) 2. *? Cavolinia* sp. 3. *Arenicola*-like borings filled by limonite, very small.
No. 2098	1. *Styliola* sp.	1. *Vaginella* cf. *rzehaki* Kittl 2. *V. calandrellii* (Michelotti) 3. Small *Arenicola*-like borings filled by limonite.
No. 11781	1. *Vaginella labiata*	1. *V. labiata* aff. *V. testudinaria* (Michelotti)
No. 11782	1. *Vaginella labiata* 2. *V. rotundata*	1. *V. labiata* 2. *V. rotundata*
No. 11783	1. *V. labiata*	1. *V. (?) calandrellii* (Michelotti) 2. *V. rotundata*

c) Specimens from west of Nizip, in Euphrates valley.

	Blanckenhorn's determinations	Corrections and additions
No. 2095	*Balantium flabelliforme*	*Clio* cf. *C. multicostatum* (Bellardi)
No. 2099	*Tentaculites cretaceus*	*Hyalocylis euphratensis* Avnimelech
No. 2100	*Tentaculites cretaceus* (together with *Terebratula nicaisei* Coquand)	1. *Clio cretaceum* 2. *Clio* cf. *C. multicostatum* (Bellardi) 3. *? Cavolinia* sp. 4. *Vaginella rotundata* 5. *Dentalium* sp. (imperfect fragment) 6. *Arca* sp. (imperfect fragment) 7. Indeterminate fragment of a Terebratuloid of Tertiary affinities

d) Specimens from Hammam Ak Deniz, on the east side of Lake Antiochia. Reg. No. 2097.

Blanckenhorn's determination	Correction
Creseis sp., aff. *spinifera* Rang and *C. subulata* d'Orb.	*Styliola* sp., aff. *S. subula* (Quoy and Gaimard)

subulata Quoy and Gaimard (error: it should be "*subula* (Quoy and Gaimard)"), Blanckenhorn, p. 600, pl. 22, fig. 5.
1890. ——, Blanckenhorn, p. 119, pl. 9, fig. 19.
1891. *Styliola*, Blanckenhorn, p. 65.

Many small brown spine-like impressions in grey, *Globigerina-Orbulina* marl. The differences between *Creseis spinifera* Rang and "*Creseis*" *subula* (Quoy and Gaimard) are too minute to be distinguishable in a limonitized impression. Both species exist today in the Mediterranean and are ubiquitous. "*Creseis*" *subula* (Quoy and Gaimard) is quoted by Thiele (p. 401) as belonging to the genus *Styliola* (Lesueur) Blainville 1827. According to Reuss (p. 145, pl. 6, fig. 10) it occurs in the Lower Miocene of Wieliczka (southern Poland, east of Cracow).

FIG. 2—*Styliola* aff. *S. subula* (Quoy and Gaimard). The same figure as in Blanckenhorn, 1889 and 1890, slightly modified to accord with original specimen, ×2.

Locality: Hammam Ak Deniz, in the Antiochia depression, east of Lake Amouk (=Antiochia). Reg. No. 2097.

Age: Evidently not older than Middle Miocene (Vindobonian = Helvetian), but possibly younger (?Lower Pliocene).

Genus VAGINELLA Daudin 1802

VAGINELLA ROTUNDATA Blanckenhorn

Figure 3

1889. *Vaginella rotundata* Blanckenhorn, p. 599, pl. 22, fig. 4a, b.
1890. *Vaginella rotundata* Blanckenhorn, p. 119, pl. 9, fig. 18.
1891. "*Pteropoda*-remains" e.p. Blanckenhorn, p. 53 and 56.
1897. *Vaginella acutissima* Audenino, p. 100, pl. 5, fig. 7.
1900. *Vaginella acutissima* Audenino, Verri and Angelis d'Ossat, p. 269.
1904. *Vaginella acutissima* Audenino, Sacco, p. 15, pl. 4, fig. 13.

Although Blanckenhorn's type as figured by him, is only a fragmental impression, there seems to be no doubt that it is identical with much the better documented *V. acutissima* Audenino. Characteristic are the slender form and oval cross-section. Possibly because *V. rotundata* was assumed to be of Senonian age the probability of its identity with *V. acutissima* was not considered by Audenino and other authors.

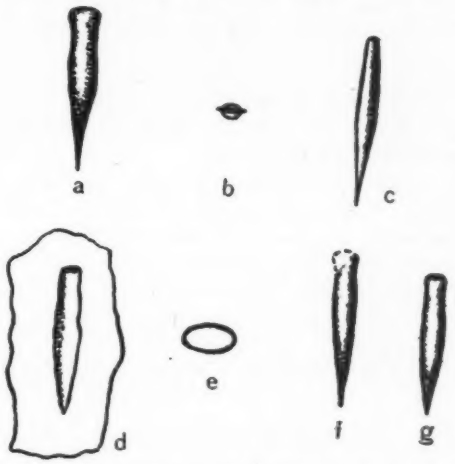

FIG. 3—*Vaginella rotundata* Blanckenhorn. *a*, *b*, *c*, "*V. acutissima*" according to Audenino, 1897 (*a*, frontal view; *b*, median and appertural cross section, *c*, side-view). ×2. *d*, *e*, After Blanckenhorn, 1889 and 1890; (*d*, fragmental impression ×2; *e*, median cross section, ×4); *f*, original drawing of the specimen No. 11783; *g*, No. 11782, both ×2.

Vaginella acutissima is known to occur in the Middle Miocene (Helvetian) of Piedmont and Umbria in Italy. This is the probable age of the outcrops with *V. rotundata* in Northern Syria and in Tauric Anatolia.

Localities: (1) Bab el Limun, between Aleppo and Birecik; (2) west of Nizip, west of the Northern Euphrates. Reg. Nos. 11782, 11783, 2100.

Age: Middle Miocene (Vindobonian = Helvetian).

VAGINELLA CALANDRELLII (Michelotti)

Figure 4

1847. *Cleodora calandrellii* Michelotti, p. 147.
1872. *Vaginella calandrellii* Michelotti, Bellardi, p. 34, pl. 3, fig. 17.
1888. *Vaginella calandrellii* Michelotti, Benoist, p. 30, pl. 2, fig. 5a, b, c.

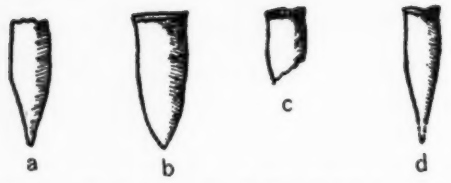

FIG. 4—*Vaginella calandrellii* (Michelotti). *a*, After Bellardi, 1872, ×1.5; *b*, after Blanckenhorn, 1889 and 1890, ×2; *c*, original drawing of specimen No. 11783, ×1.5; *d*, No. 2096, ×1.5, same specimen figured by Blanckenhorn (b).

This species is reported to occur in Lower and Middle Miocene strata of the Piedmont and Southern France.

Localities: (1) In the valley of Nahr el Kebir, near Safkoun; (2) at Bab el Limun, between Aleppo and Birecik. Reg. Nos. 11784, 2096, 2098, 11783.

Age: Middle Miocene.

VAGINELLA cf. V. RZEHAKI Kittl
Figure 5

1886. *Vaginella rzehaki* Kittl, p. 56, pl. 2, fig. 13–16.
1889. *Styliola* sp. Blanckenhorn, e.p., p. 600, pl. 22, fig. 6–7.
1890. *Styliola* sp. Blanckenhorn, e.p., p. 120, pl. 9, fig. 20–21.
1891. "*Pteropoda*-remains," e.p. p. 53.
1897. *Vaginella rzehaki* Kittl, Audenino, p. 109.
1900. *Vaginella rzehaki* Kittl, Verri and Angelis, d'Ossat, p. 270.

Referred to this species is a fragmentary cast characterized by its nearly oval cross-section, sharp conical apex, inflated ventral side and nearly flat dorsal side. *Vaginella rzehaki* occurs in Pannonian (Moravia in Czechoslovakia etc.) and Italian Middle Miocene beds.

Locality: Bab el Limun. Reg. No. 2098.

Age: Middle Miocene.

FIG. 5—*Vaginella rzehaki* Kittl, after original figures, natural size; *d*, *Vaginella* cf. *V. rzehaki*, original drawing of the specimen No. 2098, natural size.

VAGINELLA sp. (?) V. TESTUDINARIA (Michelotti)

1847. *Cleodora testudinaria* Michelotti, p. 148.
1872. *Vaginella testudinaria* Michelotti, Bellardi, p. 35, pl. 3, fig. 18.
1889. *Vaginella* sp. Blanckenhorn, e.p., p. 594.
1890. *Vaginella labiata* Blanckenhorn, e.p., p. 119, not figured specimen.
1891. "Remains of Pteropods," e.p., Blanckenhorn, p. 45.

One mould among many specimens of *Herse senonica* (Blanckenhorn) may correspond to *Vaginella testudinaria* from Middle Miocene of Piedmont.

Locality: Near Safkoun in Nahr el Kebir Valley. Reg. No. 11784.

VAGINELLA LABIATA Blanckenhorn
Figure 6

1889. *Vaginella labiata* Blanckenhorn, p. 598, pl. 22, fig. 3 a, b.
1889. *Balantium amphoroides* Blanckenhorn, p. 598, pl. 22, fig. 2.
——. *Vaginella labiata* Blanckenhorn, e.p., p. 598.
——. *Vaginella rotundata* Blanckenhorn, e.p., p. 599.
——. *Styliola* sp., e.p., Blanckenhorn, p. 600 (not figured specimen).
1890. Do., as in 1889—Blanckenhorn, p. 119, pl. 9, fig. 16.
1891. "*Pteropoda*-remains" e.p. Blackenhorn, p. 45 and 53.
1897. *Vaginella calandrellii*, Audenino, p. 109.
1900. *Vaginella calandrellii*, Verri and Angelis d'Ossat, p. 270.
1904. *Vaginella calandrellii*, Sacco, p. 15.

Vaginella calandrellii was illustrated first by Bellardi, and later by Benoist, but neither figure shows the apertural part which was missing from their specimens. This species resembles *Vaginella depressa* Daudin but is more slender and bigger. Blanckenhorn's *Balantium amphoroides* seems to be identical with *Vaginella calandrellii*. It is certainly a *Vaginella* and not a *Balantium*. Also some other pteropod remains referred by Blanckenhorn to *Vaginella labiata*, *V. rotundata* and *Styliola* sp. belong to *Vaginella calandrellii*.

1890. *Vaginella labiata* Blanckenhorn, p. 119, pl. 9, fig. 17, a, b.
1891. "Remains of Pteropods," e.p., Blanckenhorn, p. 53.

This species cannot be identified with certainty with any other species of *Vaginella* and therefore the name must be retained,

although the type specimens are very poor and the illustrations of the author are inexact and probably combined from several specimens.

Vaginella labiata possessed a straight, lanceolate tube, 10–12 mm. long, 3–4 mm. broad, with acute apical angle of approximately 40–50°; cross-section compressed-oval; ventral surface with very delicate straight furrows, parallel and near each side; aperture slightly compressed ventrodorsally, with a very flat neck below and with both ventral and dorsal lips rounded, so that the aperture appears characteristically vaulted.

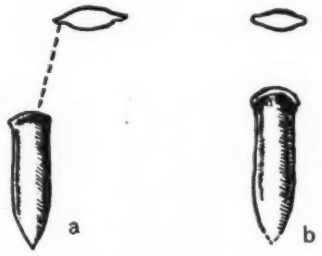

FIG. 6—*Vaginella labiata* Blanckenhorn. *a*, After original figure of Blanckenhorn, 1889 and 1890, ×2; *b*, redrawn from the holotype No. 11782, ×2.

The cross-section in Blanckenhorn's figures appears too much compressed and the sides too sharp, suggesting side-wings peculiar to the genus *Clio*. This is far from being true.

The most similar species seems to be *Vaginella testudinaria* (Michelotti) and it is not unlikely that they are identical.

Locality: Bab el Limun. Reg. Nos. 11781, 11782.

Genus HYALOCYLIS Fol 1875

HYALOCYLIS EUPHRATENSIS Avnimelech, n. sp.

Figure 7

1889. *Tentaculites cretaceus* Blanckenhorn, in litteris.

A small conical tube ornamented with fine, slightly diagonal striae. The apical end is obscured, the aperture not preserved. The specimen is 5.5 mm. long, 0.7 mm. wide near the apical end and 1.5 mm. wide near the apertural end. Cross-section seems to be perfectly round or only slightly oval near the aperture. The tube is slightly bent. The striae are very regular, not sharp but rather rounded, furrows and ridges equally broad; 12–15 striae in 1 mm at apical end, 6–7 stria per mm at apertural end;

Blanckenhorn believed this fossil to be the apical part of his *Tentaculites cretaceus*, but there are several reasons against this opinion.

FIG. 7—*Hyalocylis euphratensis* Avnimelech n. sp., holotype No. 2099, ×5.

"*Creseis*" *fuchsi* Kittl from the Hungarian Miocene and "*Creseis*" *moulinsi* (Benoist) from the Lower Miocene of southern France belong to the same genus. The recent *Hyalocylis striata* (Rang) is probably related to this species.

Locality: West of Nizip. Reg. No. 2099.

Genus CLIO Linnaeus 1767

CLIO sp., C. CARINATA Audenino?

1897. *Clio carinata* Audenino, p. 102, pl. 5, figs. 3a, b, c, d.
1904. *Balahtium* (*Flabellulum*) *carinatum* (Audenino), Sacco, p. 14, pl. 4, fig. 9.

This determination is uncertain because of the imperfect preservation of the fossil.

Clio carinata was reported by both Audenino (*2*, p. 102) and Sacco (*21*, p. 14) from the Helvetian of Monte dei Cappucini in Torino and according to Verri and Angelis, d'Ossat (*25*, p. 18, 21) it is restricted to the Miocene.

Locality: Near Safkoun in the valley of Nahr el Kebir. Reg. No. 11784.

CLIO MULTICOSTATUM (Bellardi)

Figure 8

1872. *Balantium multicostatum* Bellardi, p. 33, pl. 3, fig. 14.
1889. *Balantium flabelliforme* Blanckenhorn, p. 598, pl. 22, fig. 1a,b.
1890. *Balantium flabelliforme* Blanckenhorn, p. 118, pl. 9, fig. 15 a, b.

1891. "Remains of Pteropods," e.p., Blanckenhorn?, p. 53.
1904. *Balantium* (*Poculina*) *multicostata* (Bell), Sacco, p. 15.

Although preserved as an impression there is little doubt as to the identity of this fossil with the Lower and Middle Miocene *Clio multicostatum* from Piedmont in Italy. Blanckenhorn himself recognized its similarity to *Clio pulcherrimum* (Mayer-Eymar) which is very near to *C. multicostatum* and occurs at the same horizons.

Locality: West of Nizip on specimens Nos. 2095 and 2100, but according to Blanckenhorn also at Bab el Limun.

FIG. *8*—*Clio multicostatum* (Bellardi). *a*, After original figure of Bellardi, 1872, original size; *b*, after Blanckenhorn, 1889 and 1890, slightly modified to correspond with specimen No. 2095, ×2.

CLIO CRETACEUM (Blanckenhorn)
Figure 9

1889. *Tentaculites cretaceus* Blanckenhorn, p. 600, pl. 22, figs. 8–9.
1890. *Tentaculites cretaceus* Blanckenhorn, p. 120, pl. 9, figs. 22–23.
1891. "Remains of Pteropods" e.p., Blanckenhorn, p. 56.

This species requires special attention because it has been presumed to be an example of an archaic type of animal which persisted into the younger epochs. *Terebratula nicaisei* Coquand of the North African Cenomanian, and known also from the same horizon in Palestine (Lartet), was reported to occur with it. This brachiopod was later identified by Blanckenhorn as *Kingena blanckenhorni* Dacqué, the type of which (no more than one specimen was found!) was reported from the Campanian of Abu Roash in Egypt. Unfortunately Blanckenhorn's specimen is only a poor fragment, which certainly does not belong either to *Terebratula nicaisei* or to *Kingena blanckenhorni* and it has a rather young appearance. Thus this fossil furnishes no positive evidence for the age of *Tentaculites cretaceus*.

FIG. *9*—*Clio cretaceum* (Blanckenhorn) after original figure of Blanckenhorn, 1889 and 1890, slightly modified to accord with the holotype No. 2100, ×4.

As to *Tentaculites cretaceus* itself we refer to the quoted remark of Oppenheim (*17*, p. 82) on the great similarity of this fossil with *Tentaculites maximus* Ludwig of the Middle Oligocene of Hesse (Germany) and of the Upper Eocene of Moravia (Czechoslovakia). This last fossil was placed by Oppenheim in the genus *Balantium* (= *Clio*). According to the figures of Blanckenhorn the fossils are long-conical but almost straight tubes ornamented with prominent transverse striae. On the rock specimen occurs another fragment of this species, in which a side-wing similarly ornamented is visible. Thus Blanckenhorn's form belongs—as suggested by Oppenheim—to the tripartite *Clio*-like forms, in which the side-wings commonly break off along longitudinal grooves in such a way that separate impressions appear to be almost straight tubes. The name of this fossil, therefore, must be then changed to *Clio cretaceus* (Blanckenhorn). It is perhaps identical, or at least closely related to the Oligocene *Clio maximum* (Ludwig).

Locality: West of Nizip. Reg. No. 2100.

Genus HERSE Gistel, 1848

HERSE SENONICA (Blanckenhorn)

Figure 10

1889. *Vaginella* Blanckenhorn, p. 594.
1890. *Vaginella labiata* Blanckenhorn, p. 56.
1891. "Remains of Pteropods," e.p., Blanckenhorn, p. 45.
1934. *Vaginella senonica* Blanckenhorn, p. 275, pl. 14, figs. 201–202.

We designate figures 201 and 202 of Blanckenhorn's paper of 1934 as the type figures corresponding with the type-specimens No. 11784 in the collections of the Geological Department of the Hebrew University.

The fossils are slender, barrel-like moulds and impressions as seen from in front or dorsally, 8–12 mm. long and 2–3 mm. wide

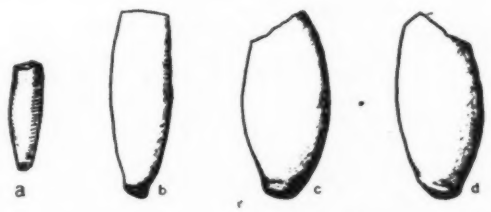

FIG. *10—Herse senonica* (Blanckenhorn). *a*, After original figure ×about 2; *b*, original drawing of one of the specimens No. 11784, cototype, ×2½; *c*, *d*, *H. S. inflata* Avnimelech, holotype No. 11784a, × about 2½.

in the middle of the tube. The frontal (ventral) surface is more inflated than the dorsal one. The median cross-section is oval, near the apertural end almost lunate and near the apical end compressed-oval to lunate. The apex itself is blunt, forming on the side of the frontal surface a small oblique vault, clearly limited by an oval rim.

Such a form characterized by a blunt apex corresponds to the genus *Herse* Gistel [= *Cuvieria* Rang 1827, non Lesueur 1807 nec (Péron) Cuvier 1817]. Our specimens seem to resemble *Herse astesana* (Rang) or *Herse intermedia* (Bellardi). Both of the latter species occur in the Lower Pliocene of Italy (*3*, p. 36, pl. 3, figs. 19–20), but Fischer (p. 456) recorded their occurrence also in the Miocene, without giving any details.

One specimen is more inflated than the other, its median cross-section is round instead of oval and also the lunate cross-section below the apertural end is broader than usual. This is designated as forma or variety *inflata*.

Locality: near Safkoun in the valley of Nahr el Kebir.

Genus CAVOLINIA Abildgaard 1791

CAVOLINIA? sp. ind.

An impression on a rock specimen from Nizip (No. 2100) may be referable to this genus.

THE PTEROPODS OF PALESTINE

Little can be said about the pteropods of Palestine. In my previous note on the pteropods of Syria (*1*) I mentioned the area of Artuf in the Shephela, on the western side of the Judean Mountains, and the region of Megiddo, south-east of the Carmel Mountains, where pteropods occur in Eocene strata.

Specimens from near Artuf are questionable and do not deserve consideration. The supposed pteropods are limonitic impressions too obscure for study.

Much more convincing are specimens from the region of Megiddo. There rock-samples containing fragmentary pteropods were collected at some 30 places. Although poorly preserved they are quite characteristic and may be used locally as guide fossils. They are enclosed mostly in silicified and often slightly bituminous *Globigerina* limestone of the Lower Lutetian. The pteropods are not well preserved and their identification as Pteropoda seems to be fully justified but their specific or even generic determination is impossible. Judging from their general form the genera *Vaginella*, *Herse* and *Styliola* are possibly represented.

In the same region of Megiddo, near the settlement of Michmar ha'Emek, on the Haifa-Jenin road, I found a loose piece of a white limestone, unfortunately of unknown origin, containing impressions and internal casts of *Clio cretaceum* (Blanckenhorn), *?Cavolinia taurinensis* (Sismondi), *?Styliola* sp.

This *Clio cretaceum* is identical with Blanckenhorn's type (No. 2100), which has been discussed, but there is much uncertainty as to the age of this specimen. The area consists of almost unfossiliferous chalky and cherty limestones of Lower Lutetian

age (lower part of Middle Eocene). It is cut by numerous inconspicuous faults which are difficult to recognize in the nearly homogenous limestone. Younger strata may be present locally for Upper Eocene and Oligocene outcrops occur only a few kilometers away. Nevertheless these fossils are probably of Lower Lutetian age. The similar (or perhaps identical) *Clio maximum* (Ludwig) occurs in the Middle Oligocene of Germany and in the Upper Eocene of Moravia.

Cavolinia taurinensis which is suggested by a mould in the same rock specimen occurs in the Middle Miocene (Helvetian) of Northern Italy.

GENERAL CONCLUSIONS

1. This investigation has furnished additional proof for the Tertiary age of North Syrian and South Anatolian pteropods and also has led to more exact stratigraphic conclusions.

2. The pteropods of the region of Lattaquia are obviously of Miocene and most probably of Middle Miocene (Vindobonian) age.

3. The pteropods of Bab el Limun, northeast of Aleppo and half way to Birecik are of the same age. Probably the same Pteropoda-horizon extends to the neighborhood of Nizip as suggested by the similarity of some species and the similarity of the rocks.

4. The Pteropoda in the region of Antiochia are certainly no older age than Middle Miocene and possibly are younger.

5. The oldest possible age of known pteropod-bearing strata in Palestine is Lower Lutetian (Middle Eocene) but possibly these rocks are younger.

6. The occurrence of Pteropoda in Syria links the south-east Mediterranean region with the Middle Tertiary basins of Italy and Pannonia.

7. Because of their aragonitic shells and consequent generally poor preservation the pteropods can not be used for exact stratigraphic differentiation, but they may be useful for more general correlations.

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BIBLIOGRAPHY AND INDEX TO NEW GENERA, SPECIES, AND VARIETIES OF FORAMINIFERA FOR THE YEAR 1943

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IN THE following bibliography for the year 1943, 76 publications devoted partly or exclusively to Foraminifera are listed. This is the smallest number of papers recorded during one year since the annual bibliographies, starting in 1931, were published in this JOURNAL. After his return to Europe the writer hopes to compile a supplement for the war years (1939–1945) especially to include the foraminiferal literature issued in Europe during this period.

The following publications contain descriptions of new forms: Nos. 4, 10, 14, 15, 16, 17, 20, 21, 22, 23, 24, 28, 32, 40, 45, 49, and 61. Colom's papers 7a, 7b, 7c, and the one by Frentzen 75, were not accessible to the compiler.

From the literature of the year 1943 are recorded 5 new genera, 133 new species, 16 new varieties (or subspecies), 2 *nomina nova* and 51 forms to which the *nomenclatura aperta* is applied. For the year 1940 one new genus, 11 new species and one new name, and for the year 1942 two new families, 2 new subfamilies and one new genus are supplemented.

The new species and varieties of the year 1943 are distributed as follows: Paleozoic 2%, Mesozoic 37% and Cenozoic 61%. Devonian accounts for 2%, Lower Cretaceous 25%, Upper Cretaceous 12%, Eocene 51¼%, Miocene 6%, and Recent 2½%. The five new genera come from Devonian, Lower Cretaceous, Eocene, Miocene and Recent. No new forms were recorded from Cambrian, Silurian, Carboniferous, Permian, Jurassic, Paleocene, Oligocene, Pliocene and Pleistocene beds, and no homonyms are listed for 1943.

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——— *keenae* Martin, **49,** p. 29, pl. 7, fig. 5. Eocene, California.
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——— *ovata* d'Orbigny, 1846, var. *cowlitzensis* Beck, **4,** p. 605, pl. 107, fig. 22. Eocene, Washington.
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——— *beatus* Martin, **49,** p. 30, pl. 8, fig. 6. Eocene, California.
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——— *whitei* Martin, **49,** p. 32, pl. 8, fig. 4. Eocene, California.
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——— *garcilassoi* Frizzell, **32,** p. 338, pl. 55, fig. 11. Upper Cretaceous, N. W. Peru.
——— *pacifica* Beck, **4,** p. 591, pl. 98, figs. 2, 3. Eocene, Washington.
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Dentalina dusenburyi Beck, **4,** p. 599, pl. 105, figs. 20, 23. Eocene, Washington.
——— *oviedoi* Frizzell, **32,** p. 344, pl. 56, figs. 9, 10. Upper Cretaceous, N.W. Peru.
Dentalinopsis chapparsi Tappan, **61,** p. 509, pl. 81, figs. 26–28. Lower Cretaceous, Texas.
——— *nodosaria* Tappan, **61,** p. 509, pl. 81, fig. 24. Lower Cretaceous, Texas.
Dictyoconus parvula Cushman and Campbell, **20,** p. 73, pl. 13, fig. 1. Middle Eocene, California.
Discorbis huascari Firzzell, **32,** p. 350, pl. 57, fig. 5. Upper Cretaceous, N.W. Peru.
——— *munutissima* Tappan, **61,** p. 511, pl. 82, figs. 5, 6. Lower Cretaceous, Texas. (Note: On explantaion to pl. 82 the species name is spelled "*minutissima.*")
Ellipsonodosaria subspinosa Cushman, **16,** p. 92, pl. 16, figs. 6, 7. Lower middle Micoene, Trinidad. B.W.I. (For: *Ellipsonodosaria* sp. Cushman and Jarvis, 1934, Contr. Cushman Lab. Foram. Research, vol. 10, pl. 10, figs. 4, 5.)
Elphidium crispum (Linné, 1758), var. *detorquens* Earland and Jepps, **28,** p. 43–47, text figs. 1, 2. (Note: Publication not seen by the compiler.)
Epistomina lenticularia Tappan, **61,** p. 512, pl. 82, fig. 12. Lower Cretaceous, Texas.
——— *limbata* Tappan, **61,** p. 512, pl. 82, figs. 13 14. Lower Cretaceous, Oklahoma.
Eponides huaynai Frizzell, **32,** p. 351, pl. 57, fig. 7 Upper Cretaceous, N.W. Peru.
——— *lodoensis* Martin, **49,** p. 23, pl. 6, fig. 8. Eocene, California.
——— *primus* Martin, **49,** p. 23, pl. 9, fig. 4. Eocene, California.
——— *zaratei* Frizzell, **32,** p. 351, pl. 57, fig. 8. Upper Cretaceous, N.W. Peru.
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Gaudryina canadensis nom. nov., Cushman, **15,** p. 28, pl. 6. figs. 7, 8. Lower Cretaceous, Western Canada. (New name for *Bigenerina angulata* (Cushman, 1927, Trans. Roy. Soc. Canada (3), vol. 21, pt. 2, sect. 4, p. 131, pl. 1, fig. 10.) Note: Cushman's reference to *Bigenerina angulata* appears to be incorrect, because this species is a biserial-uniserial form, whilc *Gaudryina canadensis* shows a triserial-biserial test.
Gaudryina (*Siphogaudryina*) *rectiangula* Martin, **49,** p. 14, pl. 5, fig. 4. Eocene, California.
Gaudryinella irregularis Tappan, **61,** p. 490, pl. 78, figs. 31, 32. Lower Cretaceous, Texas.
Globigerina decepta Martin, **49,** p. 24, pl. 7, fig. 2. Eocene, California.
——— *nitida* Martin, **49,** p. 25, pl. 7, fig. 1. Eocene, California.
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——— *naussi* Martin, **49,** p. 26, pl. 8, fig. 3. Eocene, California.
——— *nicoli* Martin, **49,** p. 27, pl. 7, fig. 3. Eocene, California.
——— *rex* Martin, **49,** p. 27, pl. 8, fig. 2. Eocene, California.
Globulina minuta (Roemer, 1838) var. *sinuata* Beck, **4,** p. 603, pl. 106, fig. 13. Eocene, Washington.
——— *redriverensis* Tappan, **61,** p. 505, pl. 81, figs. 1–3. Lower Cretaceous, Oklahoma.
Goësella gibbosa Hussey, **40,** p. 161, pl. 26, fig. 13. Eocene, Louisiana.
Gyroidina childsi Martin, **49,** p. 22, pl. 6, fig. 6. Eocene, California.
Haplophragmoides atahuallpai Frizzell, **32,** p. 337, pl. 55, fig. 5. Upper Cretaceous, N.W. Peru.
——— *zaratei* Frizzell, **32** p. 337, pl. 55, fig. 6. Upper Cretaceous, N.W. Peru.
Hastigerinella subcretacea Tappan, **61,** p. 513, pl. 83, fig. 4. Lower Cretaceous, Oklahoma.
Karreriella contorta Beck, **4,** p. 592, pl. 98, figs. 4, 5. Eocene, Washington.
——— *ovata* Hussey, **40,** p. 161, pl. 26, fig. 5. Eocene, Louisiana.
Lagena crowleyi Martin, **49,** p. 18, pl. 5, fig. 5. Eocene, California.
——— *watsonae* Martin, **49,** p. 18, pl. 5, fig. 7. Eocene, California.
Lagena? malpasoensis Frizzell, **32,** p. 348, pl. 56, fig. 25. Upper Cretaceous, N.W. Peru.
Lenticulina washingtonensis Beck, **4,** p. 597, pl. 104, figs. 18, 21. Eocene, Washington.
Lepidocyclina (*Trybliolepidina*) *batesfordensis* Crespin, **10,** p. 170, pl. 5, figs. 16–21; pl. 8; pl. 9, figs. 36–46. Middle Miocene, Australia. (For: Forma A: *Lepidocyclina tournoueri* Chapman, 1910 (non Lemoine and R. Douvillé, 1904), Proc. Roy. Soc. Victoria, new series, vol. 22, p.

295, pl. 54, figs. 1, 2, 6; for same species in: Crespin, 1926, Proc. Roy. Soc. Victoria, new series, vol. 38, p. 114, pl. 8, fig. 7; for same soecies in: Crespin, 1936, Pal. Bull. No. 2, pl. 2, figs. 16 and 23; *Lepidocyclina verbeeki* Crespin, 1926 (non Newton and Holland, 1899), Proc. Roy. Soc. Victoria, new series, vol. 38, p. 115, pl. 8, fig. 10; Forma B: *Orbitoides mantelli* Howchin, 1891 (non Morton, 1833), in Hall and Pritchard, Proc. Roy. Soc. Victoria, vol. 4, new series, p. 10; *Lepidocyclina marginata* Chapman, 1910 (non Michelotti, 1841 *Nummulites*), Proc. Roy. Soc. Victoria, new series, vol. 22, p. 296, pl. 4, fig. 5; pl. 5, figs. 1–3, and for same reference in Crespin, 1926, Proc. Roy. Soc. Victoria, new series, vol. 38, p. 115.)

——— (———) *gippslandica* Crespin, **10,** p. 165, pl. 3, figs. 1–7; pl. 6, figs. 22–28. Middle Miocene, Gippsland, Australia. (For: Forma A: *Lepidocyclina* (*Nephrolepidina*) *radiata* Chapman and Crespin, 1932, (non Martin, 1880), Proc. Roy. Soc. Victoria, new series, vol. 44, pl. 95, pl. 13, figs. 15–16, 17); *Lepidocyclina* (*Nephrolepidina*) *martini* Chapman and Crespin, 1932 (non Schlumberger, 1900), ibid., pl. 12, figs. 11–14, and for same reference in Crespin, 1936, Pal. Bull. No. 2, p. 10, pl. 2, figs. 25, 26.)

Lituola serpula Tappan, **61,** p. 484, pl. 77, fig. 19. Lower Cretaceous, Texas.

Marginulina coya Frizzell, **32,** p. 343, text fig. 2, Upper Cretaceous, N.W. Peru.

——— *lenticulinoidea* Tappan, **61,** p. 494, pl. 79, figs. 19, 20. Lower Cretaceous, Oklahoma.

——— *paucicosta* Tappan, **61,** p. 494, pl. 79, figs. 16, 17. Lower Cretaceous, Texas.

——— *planitesta* Tappan, **61,** p. 495, pl. 79, fig. 18. Lower Cretaceous, Oklahoma.

——— *stratifera* Tappan, **61,** p. 495, pl. 79, fig. 26. Lower Cretaceous, Oklahoma.

——— *variata* Hussey, **40,** p. 161, pl. 27. figs. 1–8. Eocene, Louisiana.

NODOPLANULIS gen. nov., Hussey, **40,** p. 166. Fam. Heterohelicidae. Genotype: *N. elongata* Hussey, 1940, ut infra. Eocene.

——— *elongata* Hussey, **40,** p. 166, pl. 26, fig. 11. Eocene, Louisiana.

Nodosarella robusta Cushman, **16,** p. 92, pl. 16, fig. 8. Probably Miocene, Island of St. Croix.

——— *subcylindrica* Cushman, **16,** p. 91, pl. 16, figs. 4, 5. Probably Miocene, Island of St. Croix.

Nodosaria deliciae Martin, **49,** p. 17, pl. 6, fig. 3. Eocene, California.

——— *oklahomensis* Tappan, **61,** p. 497, pl. 80, figs. 3, 4. Lower Cretaceous, Oklahoma.

——— *primitiva* Hussey, **40,** p. 165, pl. 26, fig. 1. Eocene, Louisiana.

Ophthalmidium adhaerens Tappan, **61,** p. 491, pl. 78, figs. 34, 35. Lower Cretaceous, Oklahoma.

——— *minima* Tappan, **61,** p. 491, pl. 78, figs. 36, 37. Lower Cretaceous, Oklahoma.

Palmula henbesti (Bermudez, 1937) var. *lodoensis* Martin **49,** p. 15, pl. 9, fig. 1. Eocene, California

PARANONION gen. nov., Logue and Haas, **45,** p. 177. Fam. Nonionidae; subfam. Nonioninae. Genotype: *P. venezuelanum* Logue and Haas, ut infra. Upper Miocene.

——— *venezuelanum* Logue and Haas, **45,** p. 178, pl. 30, figs. 1–4. Upper Miocene, Venezuela.

Placopsilina expansa Tappan, **61,** p. 493, pl. 79, fig. 11. Lower Cretaceous, Texas.

——— *minima*, Tappan, **61,** p. 493, pl. 79, fig. 10. Lower Cretaceous, Oklahoma.

Plectofrondicularia hedbergi nom. nov., Cushman, **16,** p. 90, pl. 16, fig. 1. Upper Oligocene, Venezuela. (New name for: *Plectofrondicularia californica* Hedberg, 1937 (non Cushman and Stewart, 1926), Jour. Paleont., vol. 11, p. 675, pl. 91, fig. 7.)

——— *whitei* Martin, **49,** p. 19, pl. 5, fig. 2, Eocene, California.

Proteonina pseudospiralis Cushman and Stainbrook, **22** p. 76, pl. 13, figs. 8–13. Devonian, Iowa.

Pseudoclavulina elongata Hussey, **40,** p. 161, pl. 26, figs. 3, 4. Eocene, Louisiana.

Pseudoglandulina marginuliniformis Frizzell, **32,** p. 347, pl. 56, figs. 20, 21. Upper Cretaceous, N.W. Peru.

PSEUDOPALMULA, gen. nov., Cushman and Stainbrook, **22,** p. 78. Fam. Textulariidae. Genotype: *P. palmuloides* Cushman and Stainbrook, ut infra. Devonian.

——— *palmuloides* Cushman and Stainbrook, **22,** p. 78, pl. 13, figs. 35–37. Devonian, Iowa.

Pullenia eggeri Cushman and Todd, **23,** p. 3, pl. 1, figs. 5–7. Upper Cretaceous, Bavaria, Germany. (For: *Pullenia sphaeroides* Egger, 1899 (non d'Orbigny, 1826), Abhandl. k. Bayer. Akad. Wiss., Munchen, II. Classe, vol. 21, p. 174, pl. 21, figs. 27, 28.)

——— *elegans* Cushman and Todd, **23,** p. 23, pl. 4, fig. 11. Recent, Pacific, Channel Islands, California.

——— *marssoni* Cushman and Todd, **23,** p. 3, pl. 1, figs. 8, 9. Upper Cretaceous, Rügen, Germany. (For: *Pullenia compressiscula* Marsson, 1878 (non Reuss, 1865), Mitth. Nat. Ver. Neu-Vorpommern u. Rügen, Jahrb. 10, p. 147.)

——— *quinqueloba* (Reuss, 1851) var. *angusta* Cushman and Todd, **23,** p. 10, pl. 2, figs. 3, 4. Eocene, Texas. (For: *Pullenia quinqueloba auct.* (non Reuss, 1851) in: Plummer, 1927, Univ. Texas Bull. 2644, p. 136, pl. 8, fig. 12; Cole, 1927, Bull. Am. Paleontology, vol. 14, No. 51, p. 32, pl. 5, fig. 15; Cushman, 1939, Contr. Cushman Lab. Foram. Research, vol. 15, p. 73, pl. 12, fig. 17; Cushman, 1940, ibid., vol. 16, p. 72, pl. 12, figs. 13, 14; Toulmin, 1941, Jour. Paleontology, vol. 15, p. 607, pl. 81, fig. 24; and Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Research, vol. 18, p. 42, pl. 7, fig. 15.)

——— *reussi* Cushman and Todd, **23,** p. 4, pl. 1, figs. 10–13. Upper Cretaceous, Germany. (For: *Pullenia bulloides* Hantken, 1875 (non d'Orbigny, 1826), Mitth. Jahrb. k. Ungar. geol. Anstalt, vol. 4, p. 59, pl. 10, fig. 9.)

Quinqueloculina goodspeedi Hanna and Hanna, 1924, var. *olequaensis* Beck, **4,** p. 592, pl. 99, figs. 3, 4. Eocene, Washington.

——— *milleri* Beck, **4,** p. 593, pl. 99, figs. 8–10. Eocene, Washington.

——— *minima* Tappan, **61,** p. 490, pl. 78, fig. 33. Lower Cretaceous, Texas.

——— *minuta* Beck, **4,** p. 593, pl. 99, figs. 5–7. Eocene, Washington.
——— *paynei* Beck, **4,** p. 593, pl. 99, figs. 11–13. Eocene, Washington.
——— *whitei* Beck, **4,** p. 593, pl. 98, figs. 6–8. Eocene, Washington.
Robertina washingtonensis Beck, **4,** p. 604, pl. 107, figs. 17, 19, 24. Eocene, Washington.
Robulus kincaidi Beck, **4,** p. 595, pl. 102, figs. 1,7. Eocene, Washington.
——— *propinquus* (Hantken, 1875) var. *cowlitzensis* Beck, **4,** p. 595, pl. 104, figs. 6, 12. Eocene, Washington.
——— *weaveri* Beck, **4,** p. 595, pl. 103, figs. 3, 8. Eocene, Washington.
Robulus ? capac Frizzell, **32,** p. 341, pl. 54, fig. 1. Upper Cretaceous, N.W. Peru.
Saracenaria bononiensis (Berthelin, 1880) var. *striatolipa* Tappan, **61,** p. 498, pl. 80, fig. 6. Lower Cretaceous, Oklahoma.
——— *callitoecha* Tappan, **61,** p. 498, pl. 80, figs. 7, 8. Lower Cretaceous, Oklahoma.
——— *duckcreekensis* Tappan, **61,** p. 498, pl. 80, fig. 10. Lower Cretaceous, Texas.
——— *mackini* Beck, **4,** p. 600, pl. 106, figs. 1, 5, 7. Eocene, Washington.
——— ——— ——— var. *cowlitzensis* Beck, **4,** p. 600, pl. 106, figs. 18, 19. Eocene, Washington.
Siphogaudryina, see *Gaudryina*.
Siphogenerina multicostata Cushman and Jarvis, 1929, var. *optima* Cushman, **16,** p. 91, pl. 16, figs. 9, 10. Probably Miocene, Island of St. Croix.
Siphogenerinoides plummeri (Cushman, 1926) var. *coya* Frizzell, **32,** p. 349, pl. 56, fig. 29. Upper Cretaceous, N.W. Peru.
Siphonina carinata Hussey, **40,** p. 166, pl. 26, figs. 14, 15. Eocene, Louisiana.
——— *claibornensis* Cushman 1927, var. *cowlitzensis* Beck, **4,** p. 608, pl. 108, figs. 15, 18. Eocene, Washington.
Siphotextularia subcretacea Tappan, **61,** p. 486, pl. 78, fig. 11. Lower Cretaceous, Texas.
Spiroplectammina acostai Tappan, **61,** p. 484, pl. 77, fig. 20. Lower Cretaceous, Texas.
——— *grzybowskii* Frizzell, **32,** p. 339, pl. 55, figs. 12, 13. Upper Cretaceous, N.W. Peru. (For: *Spiroplectoides clotho* Cushman and Jarvis, 1928 (non Grzybowski, 1901), Cushman Lab. Foram. Research, Contr., vol. 4, p. 101, pl. 14, figs. 13, 14; *Spiroplectoides* (*?*) *clotho* Cushman, 1934, (non Grzybowski, 1901), ibid., vol. 10, p. 42, pl. 6, figs. 20–23 (non fig. 19); *? Spiroplectammina rosula* Galloway and Morrey, 1931 (non Ehrenberg, 1854), Jour. Paleontology, vol. 5, p. 335, pl. 37, fig. 10; and for *Bolivinopsis clotho* Cushman, 1940, (non Grzybowski, 1901), Foraminifera, Third edit., Key pl. 26, figs. 2, 3.)
——— *richardi* Martin, **49,** p. 14, pl. 5, fig. 3. Eocene, California.
Stichocibicides subcretacea Tappan, **61,** p. 514, pl. 83, figs. 9, 10. Lower Cretaceous, Texas.
Textularia duckcreekensis Tappan, **61,** p. 486, pl. 78, fig. 10. Lower Cretaceous, Texas.
Textularia (*?*) *proboscidea* Cushman and Stainbrook, **22,** p. 78, pl. 13, figs. 29–34. Devonian, Iowa.
Tretomphalus myersi Cushman, **14,** p. 26, pl. 6, figs. 4–6. Recent, Pacific, off La Jolla, California.
Triloculina gilboei Beck, **4,** p. 594, pl. 101, figs. 1–3. Eocene, Washington.
Trochammina krumensis Tappan, **61,** p. 492, pl. 79, figs. 3–5. Lower Cretaceous, Texas.
——— *obliqua* Tappan, **61,** p. 492, pl. 79, fig. 6. Lower Cretaceous, Oklahoma.
——— *ondegardoi* Frizzell, **32,** p. 340, pl. 55, fig. 18. Upper Cretaceous, N.W. Peru.
——— *truncata* Tappan, **61,** p. 492, pl. 79, fig. 7. Lower Cretaceous, Texas.
Trochammina ? lejesmai Frizzell, **32,** p. 341, pl. 55, fig. 17. Upper Cretaceous, N.W. Peru.
TROCHAMMINELLA gen. nov., Cushman, **17,** p. 95. Fam. Trochamminidae. Genotype: *T. siphonifera* Cushman, 1943, ut infra. Recent, Caribbean Sea.
——— *siphonifera* Cushman, **17,** p. 95, pl. 16, figs. 18–20. Recent, off Porto Rico, depth 240–300 fathoms.
Trybliolepidina, see *Lepidocyclina*.
Turrispirillina subconica Tappan, **61,** p. 510, pl. 82, figs. 2, 3. Lower Cretaceous, Texas.
Unicosiphonia subcretacea Tappan, **61,** p. 508, pl. 81, fig. 21. Lower Cretaceous, Texas.
Uvigerina lodoensis Martin, **49,** p. 21, pl. 6, fig. 2. Eocene, California.
Vaginulina duckcreekensis Tappan, **61,** p. 500, pl. 80, figs. 27–29. Lower Cretaceous, Texas.
Vaginulinopsis kelleyi Martin, **49,** p. 15, pl. 5, fig. 8. Eocene, California.
——— *saundersi* (Hanna and Hanna, 1924) var. *rex* Martin, **49,** p. 17, pl. 9, fig. 2. Eocene, California.
——— ——— (——— ——— ———) var. *lewisensis* Beck, **4,** p. 598, pl. 105, figs. 3, 13. Eocene, Washington.
——— *verruculosa* Martin, **49,** p. 16, pl. 5, fig. 6. Eocene, California.
Virgulina croneisi Tappan, **61,** p. 508, pl. 81, figs. 17, 18. Lower Cretaceous, Texas.
——— *hobsoni* Beck, **4,** p. 606, pl. 107, figs. 6, 10. Eocene, Washington.
——— *implicata* Cushman, **16,** p. 90, pl. 16, fig. 3. Probably Miocene, Island of St. Croix.
WASHITELLA gen. nov., Tappan, **61,** p. 515. Fam. unknown. Genotype: *W. typica* Tappan, 1943, ut infra. Lower Cretaceous.
——— *triradiata* Tappan, **61,** p. 515, pl. 83, figs. 17, 18. Lower Cretaceous, Oklahoma.
——— *typica* Tappan, **61,** p. 515, pl. 83 (not. pl. 63), figs. 11–16. Lower Cretaceous, Oklahoma. (For: *Genus ? species ?* Tappan, 1940, Jour. Paleontology, vol. 14, p. 124, pl. 18, figs. 17, 18.)
Zeauvigerina lodoensis Martin, **49,** p. 21, pl. 5, fig. 1. Eocene, California.

LIST OF FORMS WITH NOMENCLATURA APERTA

Ammobaculites sp. Frizzell, **32,** p. 338, pl. 55, fig. 10. Upper Cretaceous, N.W. Peru.
Ammobaculoides sp. Tappan, **61,** p. 485, pl. 77, fig. 25. Lower Cretaceous, Texas.

Anomalina sp. A Beck, **4,** p. 610, pl. 108, figs. 9, 11. Eocene, Washington.
Anomalina ? sp. B. Beck, **4,** p. 610, pl. 109, figs. 6, 10, 14. Eocene, Washington.
Bolivina ? sp A Beck, **4,** p. 607, pl. 107, fig. 11. Eocene, Washington.
Bolivinopsis ? sp A Beck, **4,** p. 604, pl. 107, figs. 2, 8. Eocene, Washington.
Chilostomelloides ? sp. Frizzell, **32,** p. 352, pl. 57, fig. 13. Upper Cretaceous, N.W. Peru.
Dentalina sp. Tappan, **61,** p. 496, pl. 79, fig. 27. Lower Cretaceous, Oklahoma.
Darbyella ? sp. A Beck, **4,** p. 596, pl. 104, figs. 8, 11, 13. Eocene, Washington.
Dentalina sp. A Beck, **4,** p. 599, pl. 105, figs. 11, 17. Eocene, Washington.
——— *sp. A* Cushman and Frizzell, **21,** p. 83, pl. 14, figs. 5, 7. Oligocene, Washington.
——— *sp. A* Frizzell, **32,** p. 345, pl. 56, figs. 11, 19. Upper Cretaceous, N.W. Peru.
——— *sp. B* Cushman and Frizzell, **21,** p. 83, pl. 14, fig. 8. Oligocene, Washington.
——— *sp. B* Frizzell, **32** , p. 345, pl. 56, fig. 12. Upper Cretaceous, N.W. Peru.
Dentalina ? sp. B Beck. **4,** p. 599, pl. 105, fig. 9. Eocene, Washington.
Dentalina sp. C Frizzell, **32,** p. 345, pl. 56, fig. 6. Upper Cretaceous, N.W. Peru.
Entosolenia ? sp. A Beck, **4,** p. 606, pl. 107, figs. 29, 31, Eocene, Washington.
Frondicularia sp. Frizzell, **32,** p. 348, pl. 56, fig. 24. Upper Cretaceous, N.W. Peru.
Gaudryina sp. Frizzell, **32,** p. 340, pl. 55, fig. 9. Upper Cretaceous, N.W. Peru.
Guttulina sp. A Beck, **4,** p. 603, pl. 107, fig. 27. Eocene, Washington.
Guttulina ? sp. B Beck, **4,** p. 603, pl. 107, fig. 35. Eocene, Washington.
Hyperammina (?) sp. Cushman and Stainbrook, **22,** p. 76, pl. 13, figs. 14–17. Devonian, Iowa.
Lagena sp. A Beck, **4,** p. 602, pl. 107, fig. 26. Eocene, Washington.
Lagena ? sp. B Beck, **4,** p. 602, pl. 107, figs. 20, 37. Eocene, Washington.
Lenticulina ? sp. A Beck, **4,** p. 597, pl. 101, fig. 8. Eocene, Washington.
Marginulina sp. Cushman and Todd, **24,** p. 56, pl. 10. fig. 1. Upper Cretaceous, Texas.
——— *sp. A* Beck, **4,** p. 597, pl. 104, figs. 19, 20. Eocene, Washington.
——— *sp. B* Beck, **4,** p. 598, pl. 105, figs. 6, 7. Eocene, Washington.
——— *sp. C* Beck, **4,** p. 598, pl. 105, figs. 15, 16. Eocene, Washington.
Massilina sp. Cushman and Todd, **24,** p. 54, pl. 9, fig. 12. Upper Cretaceous, Texas.
——— *sp. A* Beck, **4,** p. 594, pl. 100, figs. 5, 6. Eocene, Washington.
Nodosaria sp. Frizzell, **32,** p. 346, pl. 56, fig. 15. Upper Cretaceous, N.W. Peru.
——— *(?) sp.* Cushman and Frizzell, **21,** p. 84, pl. 14, fig. 6. Oligocene, Washington.
——— *sp. A* Beck, **4,** p. 599, pl. 105, fig. 8. Eocene, Washington.
Planulina ? sp. A Beck, **4,** p. 611, pl. 109, figs. 11, 16. Eocene, Washington.
Pullenia ? sp. A Beck, **4,** p. 609, pl. 108, figs. 5, 6. Eocene, Washington.
Pulvinulinella ? sp. Frizzell, **32,** p. 352, pl. 57, fig. 12. Upper Cretaceous, N.W. Peru.
Quinqueloculina sp. Beck, **4,** p. 594, pl. 100, figs. 1, 2. Eocene, Washington.
——— *sp.* Cushman and Frizzell, **21,** p. 82, pl. 14, fig. 2. Oligocene, Washington.
Rhabdammina sp. Cushman and Stainbrook, **22,** p. 75, pl. 13, figs. 2–4. Devonian, Iowa.
Robulus sp. A Beck, **4,** p. 596, pl. 101, figs. 9, 10. Eocene, Washington.
——— *sp. B* Beck, **4,** p. 596, pl. 102, figs. 2, 3. Eocene, Washington.
——— *sp. C* Beck, **4,** p. 596, pl. 103, figs. 6, 7. Eocene, Washington.
——— *? sp. D* Beck, p. 596, pl. 102, figs. 5, 6. Eocene, Washington.
Saccammina (?) sp. Cushman and Stainbrook, **22,** p. 75, pl. 13, figs. 5–7. Devonian, Iowa.
Sigmomorphina sp. A Beck, **4,** p. 603, pl. 106, figs. 6, 8. Eocene, Washington.
Triloculina sp. A Beck, **4,** p. 594, pl. 100, figs. 7–9. Eocene, Washington.
Vaginulina sp. A Beck, **4,** p. 600, pl. 106, figs. 2, 3. Eocene, Washington.
——— *sp. A* Frizzell, **32,** p. 347, pl. 56, fig. 22. Upper Cretaceous, N.W. Peru.
——— *? sp. B* Beck, **4,** p. 601, pl. 106, fig. 10. Eocene, Washington.
——— *sp. B* Frizzell, **32,** p. 348, pl. 56, fig. 23. Upper Cretaceous, N.W. Peru.

SUPPLEMENT TO INDEX FOR 1940

Bulimina (?) curvisuturata Brotzen, 74, p. 29, text fig. 6, No. 4. Upper Danian, Sweden.
Bulimina plena Brotzen, 74, p. 24, text fig. 6, No. 3. Danian, Sweden.
Cibicides danica Brotzen, 74, p. 31, text fig. 7, No. 2. Upper Cretaceous to Paleocene, Sweden. For: *Anomalina grosserugosa* Franke, 1927, (non Gümbel, 1868), Danmarks Geol. Undersök., vol. 2, No. 46, p. 37, pl. 4, fig. 3.
Conorbina conula Brotzen, 74, p. 28, text fig. 6, No. 2. Danian, Sweden.
Eponides dorsoplana Brotzen, 74, p. 31, text fig. 8 No. 2. Upper Cretaceous, Sweden.
——— *frankei* Brotzen, 74, p. 32, text fig. 8, No. 3. Upper Cretaceous, Sweden. For: *Pulvinulina karsteni* Franke, 1928, (non Reuss, 1855), Preuss, Geol. Landes-Anst., Abhandl., N.F. Heft 111, p. 184, pl. 17, fig. 5.
OSANGULARIA gen. nov., Brotzen, 74, p. 30. Fam. Rotaliidae. Genotype: *Osangularia lens* Brotzen, 1940 (ut infra). Upper Cretaceous to Paleocene.
——— *lens* Brotzen, 74, p. 30, text fig. 8, No. 1. Upper Cretaceous, Sweden.
——— *plummerae* nom. nov. Brotzen, 74, p. 30. For: *Truncatulina culter* Plummer, (non Parker and Jones, 1865), Univ. Texas Bull. 2644, p. 147, pl. 10.
Pulvinulinella eklundi Brotzen, 74, p. 30, text fig. 6, No. 1. Upper Cretaceous, Sweden.
Spirillina recta Brotzen, 74, p. 28, text fig. 6, No. 5. Danian, Sweden.
——— *subornata* Brotzen, 74, p. 26, text fig. 6, No. 6. Danian, Sweden.
Valvulineria laevis Brotzen, 74, p. 32, text fig. 7, No. 1. Upper Cretaceous, Sweden.

SUPPLEMENT TO INDEX FOR 1942

Brotzen, in his paper "Die Foraminiferengattung *Gavelinella* und die Systematik der Rotaliiformes" (see Journ. Paleontology, vol. 19, No. 4, July 1945, p. 397, No. 8) published in 1942 introduces the following new categories:

EPISTOMINIDAE fam. nov. Brotzen, 1942, *ibid.*, p. 35. Includes the genera: *Epistomina*, Terquem, 1883; *Epistominoides* Plummer, 1934; *Osangularia* Brotzen 1940; *Mississippina* Howe 1930; *Anomalinella* Cushman 1927; *Pulvinulinella* Cushman 1926; *Eponidoides* Brotzen 1942; *Siphonina* Reuss 1850; *Coleites* Plummer 1934; *Siphoninella* Cushman 1927; *Lamarckina* Berthelin 1881; *Ceratobulimina* Toula 1915; *Eponidella* Cushman and Hedberg 1935; *Robertina* d'Orbigny 1846, and *Pseudobulimina* Earland, 1934.

EPONIDOIDES gen. nov., Brotzen, 1942, Sverig. Geol. Undersök,. Ser. C, No. 451, Arsbok 36, No. 8, p. 38. Fam. Epistominidae Brotzen, 1942 (ut supra. Genotype: *Eponides dorsoplana* (see above, Supplement to Index for 1940). Upper Cretaceous. Brotzen, 1940.

GLOBOTRUNCANINAE subfam. nov. Brotzen, 1942, *ibid.*, p. 28. New subfamily of Valvulineriidae Brotzen, 1942 (ut infra). This subfamily comprises the following genera: *Globotruncana* Cushman, 1927; *Globorotalia* Cushman, 1927; *Globorotalites* Brotzen, 1942; *Rotalipora* Brotzen, 1942; *Cymbaloporetta* Cushman, 1928; *Cymbalopora* Hagenow, 1850; *Cymbaloporella* Cushman, 1927, and *Tretomphalus* Moebius, 1880.

VALVULINERIIDAE fam. nov. Brotzen, 1942, *ibid.*, p. 16. Includes the subfamilies Valvulineriinae Brotzen, 1942 (ut infra); Cibicidinae Galloway, 1933; Globigerininae Cushman, 1928; and Globotruncaninae Brotzen, 1942 (ut supra).

VALVULINERIINAE subfam. nov. Brotzen, 1942, *ibid.*, p. 17. New subfamily of Valvulineriidae Brotzen, 1942 (ut supra). Comprises the following genera: *Valvulineria* Cushman, 1926; *Gavelinella* Brotzen, 1942; *Gyroidinoides* Brotzen, 1942; *Gyroidina* d'Orbigny, 1826; *Rotaliatina* Cushman, 1925; *Eponides* Montfort, 1808; *Pseudovalvulineria* Brotzen, 1942; *Stensiöina* Brotzen, 1936, and *Streblus* Fischer, 1817.

MANUSCRIPT RECEIVED JULY 16, 1945.

JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 657–658, NOVEMBER 1945

PALEONTOLOGICAL NOTES

A TECHNIQUE FOR SIMULTANEOUS SECTIONING OF FORAMINIFERA

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INTRODUCTION

A suitable technique for the mass production of thin sections should open new fields for paleontologic investigation. Statistical studies of measurements of proloculi and other internal structures, apparently, only await such a technique. In the past there has been little use made of sectioning large numbers of Foraminifera. With the orbitoids and fusulinids, in particular, sectioning is a necessary part of identification; yet, here it is seldom required that more than three oriented sections be made for the identification of any one species. In the smaller Foraminifera an occasional section is needed to determine the ontogeny of a specimen or to differentiate between microspheric and megalospheric stages in involute forms; but, as with the larger Foraminifera, one, two, or three sections are all that are needed for these purposes.

In a recent study of some siphonate Foraminifera, I found it necessary to examine many thin sections showing internal structure. The method described here was developed to provide large numbers of thin or polished sections with a minimal amount of time for preparation.

PROCEDURE

(1)—Specimens selected for sectioning are oriented in the center of a glass slide (1″×1½″) and cemented in place with gum tragacanth. For this purpose a camel's hair brush, size 00, is satisfactory. The gum tragacanth will hold the specimens in place until firmly set in cooked balsam (Dunbar, Henbest, pp. 71, 72). Care should be taken to keep specimens at least ⅛″ apart so that they may be removed one at a time without disturbing adjacent specimens. The number ground at one time is limited by this factor together with the difficulties arising when more than about one square inch of Foraminifera is ground at one time.

(2)—The slide is coated with a thin layer of liquid balsam which is then cooked to the proper toughness. The specimens should rise well above the average thickness of the balsam. This permits fast grinding and easy removal of Foraminifera from the slide.

(3)—Grinding is done by hand on a lap of plate glass using the finest abrasive obtainable. Number 1000 emery or 904 carborundum is satisfactory. Finer abrasives may be secured by stirring one of these powders in a beaker of water and decanting after coarser particles have precipitated. This decanted solution is allowed to stand until settled, after which the abrasive may be recovered. In grinding, a solution of liquid soap and water (equal parts) was found to be superior to other lubricants used to prevent cleavage fractures from appearing in calcite. This solution also aids in keeping the abrasive evenly distributed. After a few circular grinding strokes, the slide should be examined under a microscope. Large specimens will be ground first; hence, care must be exexcised to prevent cutting too deep.

(4)—As the desired structures are revealed, the specimens are removed by touching a brush dipped in xylene to the test or by reheating the slide. These removed specimens are placed, ground side down, on a second slide and attached with gum tragacanth as before. By successive grinding and removing, all specimens, though differing in size, can be sectioned through the same structures.

(5)—When all specimens have been mounted on the second slide, it is covered with balsam and heated as before. The second grinding is as simple as that for a single specimen and can be accomplished nearly as fast.

(6)—After the desired thinness is reached, new balsam may be added and a cover slip placed over the specimens.

For more detail and further refinements in technique, the following references are suggested.

BERRY, W., 1931, Sectioning orbitoid Foraminifera: Science, new ser., vol. 73, no. 1894, pp. 426, 427, 1 fig.

CAMP, C. L. and HANNA, G. D., 1937, Methods in paleontology: Calif. Univ. Press, Berkeley, 153+xxiii pp., 58 figs.

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TOLMAN, F., 1929, A note on some refinements in the technique of making thin sections of Foraminifera: Micropaleontology Bull., vol. 1, no. 10, Art. 39, pp. 1, 2.

STAINING PLANT REMAINS IN CALCAREOUS COAL BALLS[1]

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Discovery of the technique of making nitrocellulose peels from calcareous coal balls by John Walton[2] has greatly aided paleobotanists. Serial peels are possible by this method with a minimum of wastage of the preserved material in contrast to the unavoidable loss in making thin sections. Thus the peel method has made possible more complete morphological studies of preserved plant remains found in coal balls.

The preservation of plant material in coal balls ranges from nearly perfect, barring slight compression in some cases, to very poor in highly pyritic or "sulphur balls." Even where preservation is good it has often been found that all of the cellular details are not clear due to the extreme thinness of the preserved cell walls or because of localized poor preservation. William Darrah[3] mentioned a method of staining nitrocellulose peels with a 2 per cent aqueous dye solution to aid where very little of the original plant structure is preserved. Results with this method have been fair but somewhat better results have been obtained in the following manner:

After the coal ball is cut, polished and etched and the preserved material stands out in slight relief, a concentrated solution of safranine Y (fast green, eosin, gentian violet and other dyes may be used) in warm tap water is made. The etched surface is held in this solution from 30 seconds to more than one minute depending upon the individual requirements of the preserved material. The stained surface is then washed with water. It is possible to combine the dye with the acid and in this manner stain and etch at the same time but somewhat better results have been obtained by etching and staining separately.

After the etched surface has been stained, it is possible to determine the value of the material preserved within the coal ball more readily than in unstained coal balls. Thus staining aids in deciding whether the preserved material is worth further investigation because the stained plant material stands in contrast to the relatively unstained matrix. The nitrocellulose is applied in the usual manner.

This staining process is a definite help in obtaining sharper photomicrographs and should aid in critical morphological studies because the delicate cell structures which are preserved are made more easily visible. The staining process need not add more than two minutes in making each peel. The coal ball should be restained for each peel for best results.

[1] Published with the permission of the Chief, Illinois State Geological Survey, Urbana, Illinois.

[2] Walton, John, 1928, Recent developments in paleobotanical technique: Cong. l'Avancement des Études de Strat. Carbon, Compte Rendu, Heerlen, 1927.

[3] Darrah, William, 1936, The peel method in paleobotany: Harvard Univ. Botanical Leaflets, vol. 4, no. 5.

JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 6, PP. 659–660, NOVEMBER, 1945

REVIEWS

GEOLOGICAL MAP OF THE DOMINION OF CANADA, Department of Mines and Resources, Ottawa, Canada 1945. $.50.

This colored map, consisting of two sheets, measures about 4 by 5 feet and covers all of Canada at a scale of 60 miles to one inch except for the northern part of the Arctic islands which are presented in an insert at a scale of 100 miles to one inch. The geographic base appears to be very complete and shows the names of many rivers, lakes and other features that are not otherwise readily available. The location of the Alaska Highway is indicated. This base is continued beyond the boundaries of Canada to include Newfoundland (and Labrador), neighboring parts of the United States and Alaska and part of Greenland.

The geology is indicated by overprint in 32 colors divided as follows:

Instrusives 7, Pre-Cambrian 6, Paleozoic 9, Mesozoic 6, and Cenozoic 4. They contrast to clearly show the Coast Range batholith, the geologically complex Cordilleran region flanked on the east by a zone of Paleozoics, the Mesozoic Interior Plains, the Canadian Shield also flanked by Paleozoics and the region of Appalachian structure in Nova Scotia, New Brunswick and part of Quebec.

Geological data are based on investigations of the Geological Survey of Canada from its establishment to 1943, provincial surveys and other scientific sources. Many of these data, particularly in the north were derived from exploratory traverses and the map is consequently much generalized in part. The legend presents the names of some of the more widespread and generally known formations but does not indicate the regions in which they are recognized.

This map is very pleasing in its appearance and it is a most valuable compilation of information that will be of interest to many geologists outside of Canada. There seems to be some inaccuracy in the major classification of formations, however. The Canso group and Shepody and Mabou formations are included under Pennsylvanian although W. A. Bell correlates them with the Lower Namurian of Europe and consequently they are probably of Upper Mississippian age. Apparently the subdivisions termed Mississippian and Pennsylvanian are more nearly the Lower and Upper Carboniferous of Europe than the two Carboniferous systems recognized in the United States.

J. MARVIN WELLER

THE MOLLUSCAN FAMILY PLANORBIDAE, by Frank Collins Baker, University of Illinois Press, Urbana, Illinois, 1945, pp. xxxvi+530 including 141 plates, $14.50.

This volume is the last work of F. C. Baker former Curator of the Natural History Museum of the University of Illinois and during his lifetime the foremost authority on certain groups of the living and Pleistocene mollusca of North America. The manuscript, left unfinished at the time of his death in 1942 was prepared for publication with collations, revisions and additions by H. J. Van Cleave of the Department of Zoology of the University of Illinois.

The earliest representatives of the Planorbidae occur in America in the Morrison formation and 63 fossil species have been described. The Pleistocene species, which are mostly identical to modern forms, are common in many fresh water deposits associated with the drift sheets.

This work is divided into two parts, the first, devoted to classification and general morphology, also contains chapters on ecology, embryological development, distribution, and history of classification. It is mainly devoted to a new classification in which four subfamilies, 34 genera and 18 subgenera are recognized. Of these 1 subfamily, 1 genus and 2 subgenera are new and one new generic name is proposed to replace a homonym. Also considered are one subfamily and two genera of uncertain affinities, one genus recently transferred to the Bulimidae and two genera wrongly referred to the Planorbidae. Most of the descriptions of these groups include exhaustive sections on their anatomy based on the dissection of 725 specimens belonging to 80 species and races of the family many of

them from distant countries. Lists of valid species, recent and fossil and notes on distribution both geographic and geologic are given for most of the genera and subgenera.

Part 2 was planned to be a monograph consisting of full descriptions and illustrations of all species of the Planorbidae inhabiting North and South America. The author's voluminous notes representing investigations carried on over a period of 25 years were not complete enough, however, to permit their being edited for publication. This part, therefore, consists only of the descriptions of 9 new species and 17 new varieties, 17 from the United States, 7 from Canada and one each from Cuba and Nicaragua.

Of the plates, 74 consist of anatomical drawings by the author, 65 are photographs of shells and 2 combine both drawings and photographs. All but 6 of the photographic plates were prepared by Mr. Baker and the others were made up from plainly labeled photographs. They illustrate 270 species and varieties.

Unfortunately this great work was not completed but Part 1 includes most of the material of interest to paleontologists and the classification and descriptions of all super-specific groups will be most useful to students of fresh water Mesozoic and Cenozoic gastropods. Dr. Van Cleave is to be congratulated on the excellence of his labor of love in preparing this material for publication.

J. M. W.

ERRATA

MIDDLE TERTIARY OSTRACODA

Further study has revealed erroneous generic placement of the form described as *Alatacythere westi* in my paper on some Ostracoda from subsurface middle Tertiary beds of Texas in this Journal (vol. 18, p. 158, pl. 28, figs. 3, 10, 1944). The hinge structure and other shell characters are indicative of the genus *Brachycythere* Alexander, and hence the species should be known as *Brachycythere westi* (Stephenson). The name *Cythereis pipkinensis* has previously been proposed (Jour. Paleontology, vol. 19, p. 411, 1945) to replace *C. hannai* in this paper (p. 157).

Doctor Henry V. Howe has advised that I created a homonym in describing *Cythereis verrucosus* in this report (p. 157, pl. 28, fig. 15). This name is preoccupied by *Cythere* (*Cythereis*) *verrucosa* A. E. Reuss (Ein Beitrag zur Paläontologie der Tertiärschichten Oberschlesiens: Zeitschrift der Deutschen geologischen Gesellschaft, vol. 3, p. 178, 1851). A possible earlier use of the name is referred to vaguely and has not been confirmed. The new name *Cythereis ellisi* Stephenson is here proposed to replace the homonym *C. verrucosus* Stephenson. This new name is in honor of Mr. A. D. Ellis, Jr., in recognition of his work on the Foraminifera of these strata. My thanks are extended to Doctor Howe for his assistance.

MORTON B. STEPHENSON

EXPLANATION, PLATE 53

1–4	Is correct.	*Acicularia schenckii.*
5–6	Is correct.	*Cymopolia sp.*
7–8	Is correct.	*Dactylopora cylindracae.*
9	Should read:	*Cymopolia elongata.*
10	Should read:	*Larvia* (*Parnesina*) *encrinula.*
11–14	Should read:	*Larvia* (*Parnesina*) *davisi.*
15–18	Should read:	*Larvia* (*Parnesina*) *encrinula.*
19–21	Should read:	*Neomeris* (*Decaisnella*) *annulata.*
22	Should read:	Pia's reconstruction of *Mizzia.*
23	Should read:	*Mizzia* limestone.
24–28	Should read:	Diagrams showing arrangement and position of spore cases among the Corallinaceae.
24	*Lythophyllum.*	
25	*Corallina.*	
26	*Solenopora.*	
27	*Archaeolithothamnium.*	
28	*Lithothamnium.*	

Figures *1* to *21* from Morellet, British Museum 1939; *22*, and *24* to *28* after Pia, 1927.

J. HARLAN JOHNSON

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